"NATURE". DECEMBER 5, 1959

REVIEW ISSUE

NATURE

A Weekly Journal of Science

Vol. 184, No. 4701 SATURDAY, DECEMBER 5, 1959 2s. 6d.

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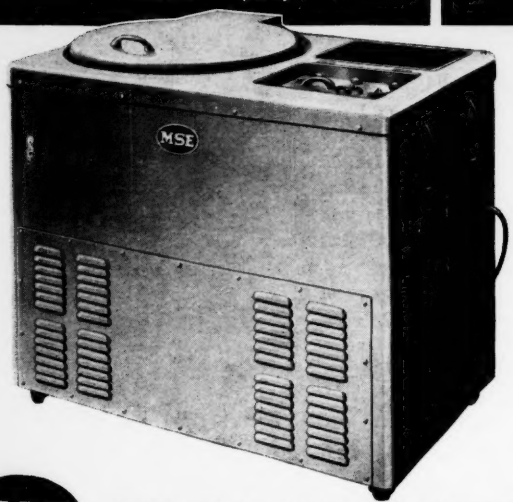

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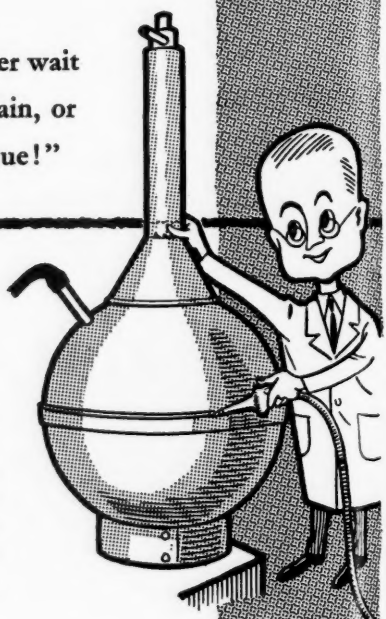

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FUTURE OF BROADCASTING AND TELEVISION

THERE are few more important questions for mankind to-day than that of the creative use of the mass media, and recent evidence of the abuse or wasteful use of television or of broadcasting only accentuates the urgency of determined efforts to discover effective ways of using the immense powers of these media over the minds of men and women and young people for creative and positive purposes. The urgency of this problem was well indicated by Alderman F. J. Stott, of Plymouth, speaking on the public library as a major instrument of education, in an address to the Library Association at its annual conference in September. Alderman Stott stressed indeed rather the threat to the balanced development of the individual members of our society under present conditions, and it was Prof. L. Hogben who referred to the immense positive possibilities of the wise and imaginative use of both sound broadcasting and television in solving some of our current educational problems, especially those arising out of the shortage of teachers.

It was accordingly a timely and public-spirited act on the part of *The Twentieth Century* to devote the whole of its November issue to the subject of television in Great Britain, with the declared object of elucidating ways in which television could be put to creative use. Comparatively few constructive suggestions emerge, in fact, from a series of highly interesting articles, among which those of Dr. J. Trenaman, Mr. Gordon McLachlan and Mr. Ed. Murrow stand out; but the articles certainly illumine the main issues which are urgent to-day. That is also true of Mr. Norman Collins's discussion of "Minorities and Monopolies", but his article appears to have been provoked by Mr. H. Carleton Greene's address to an association of German business men on the threats which political and commercial control offer to broadcasting: provoked almost to the point of obsession, Mr. Collins is betrayed into too many loose and dubious assertions.

Not the least valuable contribution, however, is the introductory editorial note, which makes an important point that, as is duly noted, the British Broadcasting Corporation itself cannot urge: while the B.B.C. for many years has been changing its approach and no longer seeks to impose what it thinks good, appreciating that there is a much wider range of good things than it once believed and offering to share them with those who want them, it has, in its turn, set standards of balance and taste to which commercial television has had, in part, to conform. Nevertheless, while the Corporation's task is to provide a balanced output of opinion, information and entertainment, and to cater for important minorities as well as the majority, there is a large public which looks to television solely for light entertainment. A serious programme accordingly loses for the B.B.C. much of its audience if its rival is showing something lighter; and if the B.B.C. lost its mass audience, if it was content merely to cater for the serious minority, viewers would ultimately resent paying for a service that was not catering for them.

This situation may well account for whatever confusion or hesitancy may seem to characterize B.B.C. policy; but no Government would stand out against public feeling or could be trusted to subsidize the B.B.C. from general government funds, and for that reason it is suggested that the B.B.C. needs now an additional channel so that it can cater for minority and majority interests throughout the entire broadcasting day. In its latest annual report the Corporation again pleads for a third television channel to be under the control of the Corporation, and claims that two B.B.C. television services could be so planned that the viewer always had a choice at any time of the evening between lighter and more substantial fare. While it can be fairly claimed that in 1958–59 the B.B.C. in such relatively serious but lively television programmes as "Panorama" and "To-night" has set a standard that can do much to enhance man's understanding of the world and his enjoyment of it, there is substance in the argument that a third television network should be allocated neither to the B.B.C. nor to the Independent Television Authority, but to a number of regional corporations, the controllers of which have no direct financial stake in the size of their audiences and who should seek to represent the people of their regions.

Mr. McLachlan's article, "The Gold Mine of Commercial Television", displays fairly enough the issues raised in commercial television and the nature of the choice that will confront the nation when the financial arrangements fall due for revision within the next five years. Mr. McLachlan suggests that the Committee of Public Accounts, in its third report for the session 1958–59, foreshadows radical proposals from the policy makers of both main political parties. He is a little uneasy as to the extent to which the public interest is likely to be served, but he sees signs that the profit motive has already lost something of its dominance and has been replaced by that of prestige, which should certainly be more sensitive to damage by abuse.

The difficulty in dealing with commercial television is not that it is concerned primarily with making profits, but the kind of popularity to which the making of those profits is geared. It may be unfair to suggest that the British Broadcasting Corporation is better than the Independent Television Authority because it does not have to make a profit; but it, too, is inhibited from frightening or jolting its audience. It shirks fundamental controversy and

when it speaks for Britain its voice must generally be the voice of a broad consensus. When Mr. Collins claims that the fears of most of those who opposed the setting up of an alternative Independent Television system have proved groundless, it is difficult to take him seriously, and, for all his fierce opposition to Mr. Carleton Greene's wish to exclude business as well as political interests from any say, direct or indirect, in the control of broadcasting, he completely fails to show that the Independent Television system is in any true sense a public service system, or that it expresses any more fully than the B.B.C. the nation's activities as a whole.

To be aware of such dangers is one thing; to determine how best to avoid them is quite another, and for positive suggestions one must turn rather to Dr. Trenaman's survey of the effects of television, to Prof. Asa Brigg's article, "The Image and the Voice", to Mr. M. Richardson's "Best and Worst of Inventions", or to a paper read by Dr. W. Belson at the British Association meeting at York. Prof. Briggs shows, for example, how much is now being done to put television in its correct place in society and in relation to the other mass media. Accurate assessment here is essential if television and sound broadcasting are to be used constructively and to the greatest advantage. That is why Dr. Belson's work on the effects of television upon the interests and initiative of adult viewers is important.

In his paper at York, Dr. Belson, from studies on B.B.C. television, showed that television reduces the frequency of occurrence of viewers' acts of initiative and also their interests in terms both of strength of identification and level of activity. Both in initiative and in interests the loss is at first substantial, but thereafter a recovery sets in which is almost complete after about five years. For a good time to come the total loss to the community is likely to be substantial, but there are exceptions, and Dr. Belson suggests that study of these exceptions may be rewarding both from a cultural and a commercial point of view.

The importance of free experiment at this stage in order to discover the full potential contribution which television may be able to make to culture, to education and to social welfare in any true sense can scarcely be over-stressed; and any decisions taken in the next five years should be such as to ensure that those to whom television—and also sound broadcasting—is entrusted are given full freedom to experiment and ample resources to do so. No sectional interest should be permitted to occupy a position which could frustrate or distort such developments, and once again the critical importance of the third network should be apparent. Any changes or new arrangements should be such as to secure as far as is humanly possible the dominance of the public interest and the conception of public service.

Perhaps the outstanding feature of this symposium of articles on television is the evidence it provides both of the immense financial interests at stake and of the little that is yet known regarding the constructive use of television. Dr. Trenaman directs attention, for example, to the premature assumption that television can communicate ideas to a much larger public than other media, and to the fact that the measured social effects of television are a good deal less spectacular than one might suppose. Nevertheless, they can be serious enough. We cannot altogether discount the tendency to insulate the viewer from the realities of the world in which we live, which Mr. Ed. Murrow finds so alarming a feature of the American system; and if Dr. Trenaman can point to numerous lines of profitable investigation, there is also much work still to be done on the technique of using television and indeed sound broadcasting, some of which could well lead to results demanding some curb on the manner in which advertising is conducted at present.

This work should not be left solely to the universities or to independent foundations, such as the Nuffield Foundation. As Mr. Richardson points out, both a lead and support could and should be given by the Government in order to enable the educational potentialities, for example, to be realized and some order established. The work already carried out by Dr. Trenaman has established beyond question the supreme importance of education here. Ultimately, the use that is made of television or sound broadcasting depends on the standards of education of the mass of the population, and that must not be forgotten in considering what contribution the new mass media can make to the removal of difficulties arising out of particular current—if possibly temporary—problems, such as the shortage of teachers of science. But if we are to use television and broadcasting wisely and effectively, either politically or culturally, as a means towards education we must know a great deal more about how to convey ideas and about the interactions of sound broadcasting, television and the other mass media—their limitations as well as their potentialities.

There is, however, one aspect of the work of the British Broadcasting Corporation which is virtually ignored in the symposium published in *The Twentieth Century*; and yet it is the one where the loss of the Corporation's monopoly and its restriction to one television channel could have the most serious effects, even if the Government's new policy in regard to overseas information services may now remove the danger of financial stringency. It could be questioned whether the external services of the Corporation could maintain its deservedly high reputation for objective and honest reporting of news if, for any reason whatever, the Corporation as a whole lost or impaired its reputation for telling the truth. That is just what could follow if the particularly close co-operation and interrelation between the Government and the Corporation were once disturbed, either in respect of the external services or of other services.

That relation is, of course, based on mutual good will and respect, and both sides—the Government and the Corporation—have a vested interest, as Mr. James Monahan recently emphasized, in keeping viable the relation between the "editorially

responsible External Services" and the co-operative, financially responsible "prescribing departments". Clearly the system seems to work, and to produce the genuine "voice of Britain"; and it is well to pause before agreeing on any changes in the relations between the British Broadcasting Corporation and the Government which might jeopardize such an asset. Objective reporting and editorial independence from the Government are not easily retrieved once sacrificed; and though the Overseas Services are only beginning to use television, too much care can scarcely be taken to avoid damaging such precious assets, or placing new obstacles in the way of their utilization, when shaping the conditions or the techniques under which the new and different powers of television are to be used. Once the fairness and impartiality of a broadcasting system becomes suspect, its authority as a source of information is destroyed; and quite apart from any short-term or long-term effects which either sound broadcasting or television may have on its constant listeners and viewers, Mr. Carleton Greene's warning is endorsed by all that has happened in the broadcasting field since his lecture was given last April.

REVIEWS

SCIENCE WRITING

The Technical Writer

An Aid to the Presentation and Production of Technical Literature. By J. W. Godfrey and G. Parr. Pp. 340. (London: Chapman and Hall, Ltd., 1959.) 45*s*. net.

WHAT exactly Ecclesiastes would have said about the making of books about the making of books—among Charles Lamb's *biblia abibilia*—we cannot know, but so shrewd an observer would surely have noticed that there seems nowadays to appear a steady stream of books about the writing, typing, editing, printing and publishing of scientific material. But perhaps the book to end books of this kind is the one before me, which probably deals more extensively than any other in English, on either side of the Atlantic, with every stage in the production of scientific and technological printed documents, from papers and pamphlets to text-books and encyclopædias.

It is implicit in the authors' undertaking that good must come of the writer's knowing something about the procedures that are the responsibilities of the compositor and the 'Reader of the Press', who are going, respectively, to set his manuscript in print and to correct its first proofs. What is not so certain is whether the authors also think that it would be good for the latter two craftsmen to know something about the first one's problems. For the most part, those at the publishing end of the chain have to gather piece-meal all they need to know about the scientist's literary habits—if anything so varying and variable can be described as a habit. This book will certainly make the task easier, in spite of the fact that it seems primarily intended for the instruction of those engaged in the pre-printing part of producing "Technical Literature".

This, the comprehensive if somewhat vague title of the book's first chapter, is there defined more precisely, and it becomes evident, as is stated by the authors and seems inevitable from their own technical backgrounds, that there is a bias towards engineering and allied subjects, including physics, in the illustrative examples they have chosen. This in no way detracts from the value of the book for those practising other disciplines, and for two reasons: first, there are many problems of presentation common to all scientific disciplines and their technologies; secondly, the call for neatness and exactness in both text and illustrations is probably greater in physics and its applications than in any other scientific field, so that the methods used to achieve them may be studied with advantage by those who are not engineers.

Chapters 2 and 3 deal, respectively, with "The Technique of Technical Writing" and with "Style and Presentation". In some ways they are the least satisfactory chapters in this immensely well-informed useful book, if only because they take insufficiently into account, again perhaps because of the general bias towards physics and its technological offspring, the great variety of journals spread over half a dozen or so major sciences and their numerous applications, with a bewildering mass of differences in conventions and 'house rules'. Moreover, I have an uneasy feeling that the authors, who in general write lucidly and economically, are possibly not the best mentors on the writing of English. My suspicions about this matter were first aroused by the fact that they recommend, and rightly so, Fowler's "Modern English Usage" as one of the books always to be consulted, and so presumably to be followed, by the scientific writer, yet seem themselves unable to adopt, or to be unaware of, Fowler's still valid distinctions between 'which' and 'that' as relative pronouns.

From Chapter 4 ("Illustrating the Text") on the book becomes increasingly concerned with mechanical rather than with intellectual processes, so that Chapters 5, 6, 8 and 9 describe, in that order, "Printing Processes", "Setting Out the Text", "Typography for Technical Publications" and "Set-up of a Technical Publications Unit". Intermediate in concern with hand and brain are Chapters 7 and 10, which deal with "Editorial Procedure" and with "Technical Authorship"; the latter phrase is not particularly illuminating, but the chapter covers an attractive medley of often apparently trivial matters, though they occasionally may assume frighteningly large proportions, such as the preface, the 'blurb', indexing, copyright, defamation, translation. The book ends with four useful appendixes (wrongly called 'appendices' by the authors, who in this matter follow the bad example set by some official publications).

In one appendix the authors rightly insist on the duty of all writers (and they might perhaps have added of all editors too) to stick to the British Standard 1219, from which they quote substantial portions, when correcting proofs. In subsequent editions they will doubtless direct attention also to the British Standard 2509 (Periodicals of Reference Value: Form and Presentation), which has become available since their book was first published. What

I should have liked, however, is rather more emphasis on two additional essentials.

First of all, long before the proof-reading stage is reached, the correct conventions should be followed when indicating on the manuscript (which must be typewritten) how and where particular words and phrases are to be set in print. Thus nothing is more infuriating to an editor (or misleading to a compositor) than use of the single underline to indicate, for example in the list of 'references', both the setting of journal names (or their abbreviations) in italics and the setting of volume numbers in 'bold' type ; and this leads me to the second 'must'.

The authors of scientific papers—and it applies to them much more than to pamphlets and books and other non-periodical publications—are under both a practical and a moral obligation to study meticulously, and having studied to follow just as meticulously, the exact conventions observed in the journals to which they intend submitting manuscripts. In such matters as the use of italics, already referred to in a slightly different connexion, or of 'full-stops' after abbreviations and captions, the particular system of references used (as distinguished by the authors on pp. 95 *et seq.*) and the arranging of headings and side-headings, previously published papers in each individual journal must be examined. The method and place of inserting tables and illustrations, and also of their legends, and in particular how much, if anything, is to be put on graphs besides points and lines, are almost always covered by the "Instructions to Authors" issued by or in many journals.

There are two reasons why the author of a paper should take all possible trouble to reduce to a minimum the need for editorial amendment of his manuscript. First, he will thereby establish some degree of confidence towards himself not only from the editor but also from any assistant editors or referees to whom his draft is submitted ; a reputation for scrupulousness in the preparation of manuscripts for the press cannot harm and may enhance the author's reputation for general reliability, even in his own field of science. Misdemeanours in these matters are, by that same token, seldom forgotten.

The second reason is simply good manners. Many editors and referees acting for scientific and technological journals, especially those that primarily cover the basic sciences and are published by learned societies, work in a purely honorary capacity, being already fully employed in research, teaching or administrative jobs undertaking their additional tasks as labours of love. Anyone who, through carelessness or laziness, increases their work unnecessarily—and indeed this is also true, *mutatis mutandis*, for the paid editor—is simply guilty of gross discourtesy to a scientific colleague. The matter is one neither of science nor of English, but just of professional courtesy.

"The Technical Writer" will undoubtedly help to smooth the path between the taking of scientific or technological action and its description in print. It must be on the library shelves in every department of every institution in which individuals prepare papers for publication in scientific, technological and technical journals. Some senior members of such institutions, especially if they are involved in producing books as well as papers, might with advantage possess their own copies. For editors and referees and their associates on editorial boards and publication committees, possession of this book is obligatory. Above all, when the young and the not-so-young author is putting the final touches to his draft before submitting it for publication, let him think of the editor, whose editorial duties are so well made clear in this book, and remember that there, but for the grace of God, may he one day go—and act accordingly.

A. L. Bacharach

NEWTONIAN DOCUMENTS

Isaac Newton's Papers and Letters on Natural Philosophy and Related Documents

Edited with a General Introduction by I. Bernard Cohen. Assisted by Robert E. Schofield. Pp. xiii + 501. (Cambridge : At the University Press, 1958.) 70*s*. net.

THE study of the history of science is still seriously hampered not only by the lack of enough good secondary works but also by the unavailability of major sources. Fortunately as regards the study of Newton the situation is improving : an English translation of the "Principia" is in print, and a *variorum* edition promised ; the "Opticks", with adequate introductory material, has been reprinted recently ; the Royal Society edition of Newton's correspondence is eagerly awaited ; and a Leverhulme award has been made for the study of Newton's mathematical papers.

The present work is a further important contribution in this field. It "brings together for the first time Newton's scattered papers and letters on natural philosophy (excluding mathematics, pure theology, and biblical chronology) as they were actually available *in print* during most of the 18th century". Apart from the "Principia", the "Opticks" and the comparatively uninfluential "Optical Lectures", the papers reprinted in this volume represent "the complete corpus of Newton's writings on physical science that actually influenced the scientists and thinking men of the 'Age of Newton'."

The first group of scientific papers comprises Newton's "New Theory about Light and Colors" and the documents of the controversy to which this gave rise, together with his second paper on the subject (read to the Royal Society during 1675–76 but not published until 1757) and his papers on the improvement of the telescope. In all, these account for nearly half the book. It is of the greatest convenience to have the objections raised against Newton's theory and his replies collected together in a single volume ; and the reader will have sympathy with Newton's later remark to Leibniz, "I was so persecuted with discussions arising from the publication of my theory of light, that I blamed my own imprudence for parting with so substantial a blessing as my quiet to run after a shadow". T. S. Kuhn's twenty-page introduction to this section will greatly help the reader to thread his way through the controversy, even if he feels at times that Mr. Kuhn is perhaps too critical of Newton. But there is no doubt that Newton brought many of the troubles on himself by leaving his original exposition seriously incomplete.

The remaining papers form a miscellaneous collection on chemistry, atomism, the aether, and heat, and there is a short introduction by Marie Boas. There then follow letters from Newton to Bentley "containing some arguments in proof of a deity", with the famous passage in which Newton asks

Bentley not to ascribe to him the notion of gravity as "essential and inherent to matter"; Bentley's lectures on "a confutation of atheism from the origin and frame of the world"; Halley's review of the "Principia" and the account of Newton's work which he wrote for presentation to King James; the first biography of Newton, Fontenelle's "Éloge"; and, as an appendix, an index to the references to Newton in Birch's "History of the Royal Society".

Apart from the general introduction by I. B. Cohen, the introductions to the various sections, and the appendix, the whole of this volume is already available to scholars with access to a good library. Those who are not so fortunate will benefit most from the book; and teachers of the history of science will at last be able to give their students an opportunity to study Newton's mind at work. But one may perhaps question whether the best methods have been adopted. In every case the papers and letters are reproduced facsimile. Obviously one must have the original diagrams reproduced facsimile, if only because their shortcomings led to misunderstandings; equally obviously, if one is to study the impact of Newton on the eighteenth century, one must read him in the sources available in the eighteenth century. But does one need to work with the type then used, and to correct the misprints oneself? Some papers are printed first in Latin and then—for some reason still facsimile—in a nineteenth-century translation. On the other hand, Fontenelle's "Éloge" is given only in English, although Gillispie in his introduction says the translation "is frequently clumsy and nowhere better than adequate". It is difficult to understand why the whole was not reset in modern type, with misprints corrected and with footnotes giving at least the pages for reference back. But this is to say only that a very useful book might have been better.

M. A. HOSKIN

A RELIGION OF MAN?

Concerning Human Understanding

Essays on the Common-sense Background of Philosophy. By Prof. Nikunja Vihari Banerjee. Pp. 333. (London: George Allen and Unwin, Ltd., 1958.) 30*s*. net.

PROF. N. V. BANERJEE, in his recently published book entitled "Concerning Human Understanding", has in fact made a collection of a number of his essays which were written over a period of twenty years.

The title is slightly misleading as the essays of Banerjee are concerned primarily not with the theory of knowledge or understanding but rather with a quest for a religion which will unite (in a sense) the conflicting values of oriental and occidental cultures.

These culminate in a final essay (Part 4 : 5) which is in fact a strong recommendation to the world of "the principle of love and kindness in the will of man, and in the world of human affairs, in order that power, and law and institutions, instead of having to exercise relentless authority and despotic rule over man, may be dedicated to the cause of humanity and consequently the world that is to sustain man from the cradle to the grave may become as good as possible and really human. And this suggests the remedy for the crisis of civilization which seems to have reached its climax in our day" (p. 324).

Prof. Banerjee takes Jesus as the supreme example of a dedicated life, such as he advocates. Banerjee has the advantage of being well acquainted with both the chief "Eastern" religious cults and with Christianity in its "Western" expression.

He is severely critical of what he calls "the latest phase of human civilization", in particular of the contrast between the extending achievements of natural science, on one hand, and, on the other, the activity of "political organizations, headed by the State", which are apt to determine man's present as well as his future, and which, according to Banerjee, are approaching Nature in what he calls its irrational and inhuman quality. It is in this context that Banerjee writes with most emphasis of "the failure of civilization".

He writes that man is hostile to and divided against himself in an unprecedented way. Nature is also hostile to man, but this is inevitable, while man's hostility to himself is suicidal.

In what he claims is a historical retrospect, Prof. Banerjee contrasts "the religion of God or gods", for which religion Nature is an object of *fear* (my italics), with what he calls "the religion of man".

To overcome the fear of Nature, Banerjee contends, is not enough. Mankind needs to keep his awareness of the hostility of Nature as a kind of stimulus (p. 325).

"The remedy" is approaching. It increases peace with Nature (*loc. cit.*). Here again the Eastern and Western mind are contrasted. Western civilization tends to distract the attention of man from what is wrong in himself, while on the other hand, oriental civilization is conspicuously introspective. Hence, according to Banerjee "the developed eastern mind" is more aware of the problem of liberation.

This book is readable and challenging, but it is doubtful whether the author succeeds in providing sufficient evidence for his sweeping generalizations, for example, about theories of knowledge (Parts 1 and 2), and about philosophy generally, including the theory of value (Part 3). It is also regrettably doubtful whether or not he succeeds in making plausible the more optimistic parts of his book, that is to say, those in which he appears to recommend a confident expectation of the reconciliation of all the opposed tendencies (for example, between Eastern and Western thought) which he clearly and eloquently describes.

D. J. MCCRACKEN

HUSSERLIANA COMPLETED

Edmund Husserl

Erste Philosophie (1923/24). Zweiter Teil: Theorie der Phänomenologischen Reduktion. Herausgegeben von Rudolf Boehm. (Husserliana, Band 8.) Pp. xliii + 594. (The Hague: Martinus Nijhoff, 1959.) 26.75 guilders, paper bound; 32 guilders, cloth bound.

WITH the appearance of this part, the plan to issue eight volumes of the works of the great master of phenomenology has reached fruition. The Husserl-Archiv at Louvain has erected as enduring a monument to his memory as can be imagined. Scholars in this field are thus obliged to study such a pre-suppositionless philosophy to the limit of their powers, not only for its own sake but in due recognition of its place as a basis for all knowledge. Whether the emphasis is mathematical or psychological, or anything in between, the need is for

rigour and the re-establishment of an acceptable first philosophy (re-establishment because the necessity was clear enough to Aristotle; then as now, there will always be links with theology whether seen overtly or not). The passage of some twenty-three centuries has but underlined mankind's urge to re-discover metaphysics (as first knowledge), not merely as a matter of professional controversy but as an essential stance for human thought in every sphere.

Before going further, a cordial tribute is fully due to the editor of this member of the series (and of No. 7 also), Dr. Rudolf Boehm, for the immense labour which he has expended upon his task. I was privileged to catch a glimpse of the work in progress at Louvain, and to participate for an hour or two in discussion. Perhaps nowhere else in the world to-day can epistemology be better experienced than in that upper room furnished in the Cardinal Mercier Place.

The book now before us is the second part of Husserl's "Erste Philosophie" (1923–24), that is, that concerned with the theory of phenomenological reduction. It consists of four main sections with an editorial introduction, together with a number of supplementary passages, and an appendix. The core is the assemblage of lectures 28–54 inclusive which, with numbers 1–27 (Volume 7), were delivered by Husserl before the University of Freiburg-im-Breisgau. Section I deals with preliminary mediations upon the apodeictic beginning of philosophy. Section II provides a *critique* of experience, the first approach to transcendental reduction. Section III discusses the phenomenology of this process, the second approach to phenomenological reduction. Section IV brings together phenomenological psychology, transcendental philosophy and phenomenological philosophy.

Since the central theme presents with the utmost rigour the universal question of the possibility of 'knowing' the world around us in terms of a proper relationship between objective time and subjective time-consciousness, it is well to recollect the three kinds of knowledge commonly accepted by scholars. Thus, apodeictic knowledge is the knowledge of something which must occur, assertoric knowledge is the knowledge of what is actually happening, whereas problematic knowledge refers to the knowledge of what might occur, or at least, be capable of occurring. Much of Husserl's outlook is, technically, problematical: it is here that his work touches the domain of discovery as if to say 'so and so is possible'.

The value of this for natural science lies perhaps in the augmented part played by probabilities in modern physics. The whole focus of phenomenological reduction is upon not merely the possibility but the necessity of avoiding immediate judgment over a wide field of human cognition. Formally, this is likely to remain inevitable, but in the applied sciences it may look like an insidious form of escapism. Such a view—if it exists—would seem to be mistaken; the whole of technology approximates to one great exercise, or worked example (however important and ingenious), rather than to the deliberate contemplation of fundamentals. It is not the fault of this ceaseless striving for a pre-suppositionless discipline that physics tends, in matters philosophical, to look after itself. But, on the other hand, natural science has fed back quite a few basic problems for the consideration of 'first philosophers'.

A peculiarity of this noble work, which is assessed as a major contribution to the humanities, is that it implies, to a considerable extent, self-immolation, and that not once, but twice. The first instance is that the very idea of transcendental phenomenology, so highly valued by Husserl, appears to have suffered an almost complete dissolution in this attainment of the notion of a contemporary first philosophy. The second abandonment is that of the Cartesian way as we find it in the *Ideen* and the *Méditations Cartésiennes*. Maybe this is not the one and only road to "Philosophie als strenge Wissenschaft", to which ideal Husserl remained completely loyal. It is characteristic of a mind of the first order that it can face the obliteration of the lesser by the greater without flinching, while at the same time offering us a new chapter in epistemology comparable perhaps with the advent of Descartes and all that followed it.

F. I. G. Rawlins

SUBSTANCE AND SHADOW

The Prof

A Personal Memoir of Lord Cherwell. By Sir Roy Harrod. Pp. xv+282+4 plates. (London: Macmillan and Co., Ltd., 1959.) 25*s*. net.

LORD CHERWELL'S complex life is a challenge to biography. Probably no Englishman since Francis Bacon has combined such a deep interest in natural science with so high a public office; and Cherwell's contemporaries may well be as divided in their approbation as were those of Bacon. A biography of Lord Cherwell, taking all aspects fairly into account, must therefore be a most interesting book: Lord Birkenhead has been asked to write it.

In the meantime, Sir Roy Harrod has produced a personal memoir based on more than thirty years close acquaintance with the 'Prof.'. As the author realizes, the book is at least as informative about himself as it is about his subject; this review will deal only with the new light that is thrown on Lord Cherwell. Sir Roy recounts some painful incidents in Oxford between the two World Wars; they bear credit to nobody and to no institution, and it is perhaps a pity that they could not have been left in the senior common room atmosphere in which they originated. There are, however, some interesting glimpses of Oxford twenty to thirty years ago, as seen by a humanist with an active sympathy for science. We in the laboratories often felt that there was a prejudice against science in the University, but we could not be sure that we were not being unduly sensitive. Sir Roy, as an onlooker, makes it quite clear that the prejudice did exist, and that Lord Cherwell fought it valiantly. Whatever may be said in criticism of his personal efforts in research after the First World War, he led the advancement of the Clarendon Laboratory; he was also one of the foremost in getting the place of science recognized in Oxford, and indeed in Britain generally.

Sir Roy reflects on some of the reasons for the comparatively small amount of research in physics personally undertaken by Lord Cherwell after 1919. There is one further reason that ought to be taken into account; many of us who found ourselves in positions of high activity during the War know that it was not easy to settle again into the quieter pursuit of research, particularly if it seemed that various aspects of national defence with which we ourselves had been formerly associated were not being properly developed. It is more than possible that this same uneasiness distracted Lord Cherwell; it certainly led

him to spend much effort on air defence matters after 1933.

As regards the Second World War, Sir Roy Harrod mainly confines himself to his subject's activities in the fields of economics and logistics, and these show the surprising extent to which Lord Cherwell's interests went beyond physics. The reader may, however, be led to draw an incorrect conclusion from the fact that Cherwell had eight economists on his staff in 1940, and only one scientist. The numbers do not reflect the relative depths of his interests; many of the scientific factors were so deeply in his mind that one assistant was perhaps all that he required—and in any event there were scientists throughout the Government service on whom he could always call. It is probably this field of Cherwell's activities, the use of science in war, on which least has yet been published, and which will be of the most general interest. Sir Roy hints at some of the pre-war difficulties that arose in Sir Henry Tizard's Committee for the Scientific Survey of Air Defence, in the Air Ministry, but he appears to have heard only a fragment of the story; more is to be found in Vol. 1 of Sir Winston Churchill's war memoirs. The Tizard Committee was one of the most distinguished and effective bodies ever to serve Great Britain, and it is impossible not to sympathize with the Committee which, having discussed and rejected some of Cherwell's ideas at Air Ministry level, then found them proposed afresh but unaltered in the still higher forum of the Committee of Imperial Defence. At the same time, one can appreciate Cherwell's earlier chagrin on finding that the Air Ministry, by forming the Tizard Committee, had forestalled his proposal for a committee on science in air defence at the highest political level.

Many of the details, both of this story and of others later in the War, if they are told, will not make complaisant reading. But they will be of extreme interest, and they may be expected to confirm the impression warmly given by Sir Roy Harrod that, even with the contradictions of his character, there was much to like and admire in 'the Prof.'. The wisdom of some of his acts may be questioned, but science in Britain is the stronger for his efforts.

R. V. JONES

ASPECTS OF SOLID STATE PHYSICS

Solid State Physics

Advances in Research and Applications. Edited by Frederick Seitz and David Turnbull. Vol. 4. Pp. xiv+540 (1957). 12 dollars. Vol. 5. Pp. xv+455 (1957). 11 dollars. Vol. 6. Pp. xiv+429 (1958). 12 dollars. (New York: Academic Press, Inc.; London: Academic Books, Ltd.)

THESE three volumes of a series initiated in 1955 contain seventeen articles, of length ranging from 9 to nearly 200 pages, on various aspects of solid state physics. It is scarcely possible, even if it were desirable, to attempt to give, in a single review, a critical assessment of all these articles. As the series expands, something like a balanced survey of a very wide field may be approached asymptotically by the aggregate of articles. Each particular volume, however, contains a rather mixed bag, and the only way of giving an objective indication of the contents is by listing the articles with brief annotations.

The longest article in Volume 4 is that on ferroelectrics and anti-ferroelectrics by W. Känzig, who surveys the field comprehensively, brings out the similarities and differences between ferromagnetics and ferroelectrics, and usefully prefaces the detailed accounts of particular materials by general summaries. The theory of mobility of electrons in solids is reviewed by F. J. Blatt. It is notable that, although the general principles underlying the interpretation of transport effects are well established, it is only rarely that good quantitative agreement between theoretical and experimental results has been obtained, and that, in this respect, the treatment of metals still lags well behind that of semi-conductors. The value of investigations of single crystal specimens of high purity and perfection is reflected in the account, by W. G. Pfann, of the techniques of zone melting and crystal growing. Another kind of technique is described by T. O. Woodruff in his article on the orthogonalized plane-wave method, exemplified by its application to silicon, for which the results obtained seem disappointingly inconclusive. A "Bibliography of Atomic Wave-functions" by R. S. Knox is essentially an extension to 1957 of a list of references compiled by Hartree some ten years earlier.

Volume 5 includes a full discussion, by M. H. Cohen and F. Reif, of quadrupole effects in nuclear magnetic resonance, with particular emphasis on the way in which the splitting and broadening of lines provides information about the internal electric fields in solids. Galvanomagnetic and thermomagnetic effects in metals are surveyed by J.-P. Jan, and discussed in terms of a two-band model. A unified treatment of the irreducible representations of the space groups, relevant to solutions of the Hamiltonian for perfect solids, is given by G. F. Koster, assuming a knowledge in the reader of the general theory of groups and their irreducible representations. C. C. Klick and J. H. Schulman deal with luminescence in solids, emphasizing the basic physical principles involved and discussing primarily inorganic phosphors. Shallow impurity states in silicon and germanium are treated by W. Kohn, who describes the empirical facts, and discusses the extent to which, in particular by advances in the theory of donor states, it has been possible to correlate a wide range of electrical, optical and magnetic properties.

There are seven articles in Vol. 6, as compared with five in the other two volumes, the subject-matter ranging from the primarily experimental to the purely theoretical. There is an extensive review by W. W. Piper and F. E. Williams on recent work on the complex phenomenon of electro-luminescence, with special reference to the basic mechanisms, and to the behaviour of zinc sulphide. The compression of solids by strong shock-waves is treated by M. H. Rice, R. G. McQueen and J. M. Walsh, who describe how modern high-explosives experimentation has extended empirical knowledge of pressure-volume relations far beyond the range over which precise static compressibility studies have been made. Experimental work during the past decade on secondary electron emission induced by electron bombardment is reviewed by A. J. Dekker. A much wider time range is covered by the article by M. P. Givens on experimental and theoretical work on the optical properties of metals, a subject which has fallen outside the main fields of recent research. D. L. Dexter presents a general account of the basic

theory of the optical properties of imperfections in non-metals. An article by G. Borelius on changes of state of simple solid and liquid metals is essentially a summarizing survey of a recent series of papers by him dealing with a semi-macroscopic analysis of energy, entropy and volume into vibrational and structural parts. Finally, there is an account of macroscopic symmetry and properties of crystals by C. S. Smith in which a systematic development of the formal theory is supplemented by physical arguments, and applied in the discussion of a wide range of physical properties.

There is no doubt that most of the articles in these volumes will be of value to those engaged in, or preparing to undertake research on, the topics with which they are concerned. This would hold even of articles which are essentially compilations of condensed information about work presented in many different journals, or which are advanced expositions of some particular theoretical topic. A reader with a good general background knowledge of solid state physics, for whom this series is intended, may, however, properly wish to be conducted into some more particularized field, rather than pushed into it. Such a reader will emerge from some of these articles with no clear impression at all. The writers, as guides, are often too conscientious, too modest, or just plain indifferent : too conscientious in trying to make reference to every piece of work they have been able to find ; too modest in not allowing any trace of personal judgment, even by selection, to become apparent ; or plain indifferent in not caring whether a condensed piece of theoretical exposition is likely to be intelligible to an average reader or even, sometimes, whether it is intelligible to themselves.

In these volumes there is a theoretical article which begins at a level so far beyond that of most physicists as to be virtually useless by itself in this form. Another theoretical article is a first-rate piece of exposition, at an appropriate level, though even this jumps the traces occasionally, and would be improved by the addition of a few explanatory sentences or paragraphs. On the more experimental side there is an article which contains more than seventeen pages of tables, mostly of experimental data of very specialized interest, which are completely out of place in a series of this kind. Other primarily experimental articles suffer from a congestion of factual material. In some, however, much thought has clearly been given to presenting a clear and balanced picture of a particular field, at the expense of omissions which are likely to be deplored only by a few of the less able writers of Ph.D. theses.

The adverse comments which have been made must not be taken to imply that the average standard of the articles in these volumes is unusually low ; indeed, compared with the general run of review articles, it is unusually high, in keeping with the already established reputation of the series. Even here, however, the prevalent diseases of review articles and their writers are becoming apparent : the spotted reference fever of the one, and the introversion of the other. These can be controlled, and when they are, and other more positive conditions are satisfied, review articles may result which, like a few of those here, are in their own right substantial contributions to science.

I am indebted to my colleagues Dr. P. Rhodes and Dr. E. F. W. Seymour for also reading a number of the articles in these three volumes, and giving me the benefit of their comments. E. C. Stoner

MUSIC AND ELECTRONIC COMPUTORS

Experimental Music

Composition with an Electronic Computer. By Prof. L. A. Hiller, Jr., and Leonard M. Isaacson. Pp. vii+197. (London : McGraw-Hill Publishing Company, 1959.) 46*s*. 6*d*.

So much is heard nowadays of the capabilities of the computer robot in imitating every human activity that it is not surprising to read of experiments in which the computer is made to compose music. Perhaps to say that the machine 'composes' is putting the experiments described in this book at too high a level, as probably the authors would be the first to admit. What the computer has been asked to do is, in fact, to produce a *canto fermo*, a series of notes following certain rules which every student of harmony has to practise at an early stage of the music course. Since these rules are largely negative, it is, of course, quite easy to feed into it a programme in which it may choose the next note at random, provided it does not, for example, form a tritone, jump more than an octave, and so on. The result is something which will pass a music examiner, or would have done in the past century, but is scarcely a composition. It is rather like asking a laboratory technician who can blow glass, solder, join wood and nothing more to carry out an original piece of research.

This writing of a *canto fermo* is not the sole musical experience of this particular electronic computer. There are others, and the authors have gone so far as to orchestrate them for string quartet. Read as scores (given in the text) they are not very impressive. One cannot expect to create a mechanical Bach or Mozart, but it evidently takes more than a few programmes to endow our robot with the divine afflatus which could produce even a simple folk tune. Nevertheless, these experiments are amusing and the account of them is well written, so that one does not need to be a *habitué* of the computer room to understand what the authors were planning.

E. G. Richardson

SEMICONDUCTORS

Optical Properties of Semi-Conductors

By Dr. T. S. Moss. (Semi-Conductor Monographs.) Pp. x+279. (London : Butterworths Scientific Publications ; New York : Academic Press, Inc., 1959.) 50*s*.

Fluctuation Phenomena in Semi-Conductors

By Prof. A. Van der Ziel. (Semi-Conductor Monographs.) Pp. viii+168. (London : Butterworths Scientific Publications, 1959.) 35*s*.

Progress in Semiconductors

Vol. 3. Edited by Dr. Alan F. Gibson, Prof. R. E. Burgess and Prof. P. Aigrain. Pp. viii+210. (London : Heywood and Co., Ltd., 1958.) 55*s*. net.

An Introduction to the Theory and Practice of Semiconductors

By Dr. A. A. Shepherd. Pp. 206. (London : Constable and Co., Ltd., 1958.) 18*s*. 6*d*. net.

Half of Dr. Moss's book gives a general discussion of the theory of optical effects in solids. The other half presents summaries of the optical proper-

ties of a range of semiconducting elements and compounds. Although these summaries are brief they are meaty and well supplied with references and would seem a useful supplement to a general text-book on solid state physics: a reminder of the complexity of the subject and of the tenuous physical basis of some of the more elaborate mathematics.

Prof. A. Van der Ziel has written a clear and thorough book on the present status of the theoretical and experimental work on fluctuation phenomena, or electrical 'noise' in semiconductors. Both the above books are in the series of "Semiconductor Monographs".

Volume 3 of "Progress in Semi-Conductors" includes articles entitled: the magnetoresistivity of germanium and silicon; the chemical purification of germanium and silicon; electronic conductivity of silver halide crystals; silicon junction diodes; lifetime of excess carriers in semiconductors; scattering and drift mobility of carriers in germanium; and electronic processes in cadmium sulphide. An index is provided.

Some years ago the study of silicon and germanium became a popular *folie* and vast sums have been devoted to it. But even if these elements seem predominant when looking out from the centre of a vast industrial structure built upon their semiconducting properties, the student of semiconductors should surely have the subject presented with more judiciously chosen proportions. Despite its title, "An Introduction to the Theory and Practice of Semiconductors", Dr. A. A. Shepherd's book is mainly restricted to some technological aspects of the adamantine structures.

R. A. Hyman

INTERNATIONAL CONFERENCE OF RADIO ASTRONOMERS

Paris Symposium on Radio Astronomy
Held from 30 July to 6 August, 1958. Edited by Ronald N. Bracewell. (International Astronomical Union: International Scientific Radio Union.) Pp. xii+612. (Stanford, Calif.: Stanford University Press, 1959.) 15 dollars.

MORE than 160 of the scientists who work in the rapidly growing branches of radio astronomy, or in related subjects, attended a symposium in Paris in July 1958. This was a useful preliminary meeting to the tenth Assembly of the International Astronomical Union in Moscow a month later. The volume under review contains the proceedings of the Paris symposium, and the editor and publishers are to be congratulated that they have fulfilled the time-table outlined for the symposium, and have produced this large volume of proceedings within twelve months of the meetings. The volume is divided into six parts, each of which opens with an introductory lecture given by one of the leading scientists in the field. There follow 10–30 papers, and significant contributions to the discussion which followed each paper, or group of papers. Particularly valuable are the concluding lectures at the end of each part of the book. In these lectures distinguished astronomers attempted to relate the often diverse individual papers, and to emphasize those parts of the subject where theoretical discussion or further observations seemed to be most needed.

The first half of the book deals with radio studies of the solar system. There is a short section on radio-echo observations of the Moon, and on the thermal radiation at millimetre wave-lengths from the Moon, Venus, Jupiter and Saturn. This is followed by a much longer section on radio observations of the Sun, and the classification and interrelation of the variable solar emissions.

The second half of the book contains two sections dealing with the emissions from galactic and extra-galactic sources, and the study of galactic structure by means of the 21-cm. line of neutral hydrogen. Some may regret that the papers on hydrogen line work are divided rather artificially between these parts 3 and 4 of the book, but all must welcome the successful 'marriage' of observations from Leyden and Sydney, to give a map of our galaxy which is almost complete, and very detailed. The accuracy of this work has led to a re-definition of the galactic pole which is more accurate by an order of magnitude than the earlier definition based on optical observations. The detection of radial motions of the gas in the central parts of our galaxy will act as a further stimulus to the theoretical work on the stability of spiral structures.

Section 5, on discrete sources and the universe, contains probably the most vigorous of the discussions at the symposium. This centred about the problems, first, of the great preponderance of the radio sources with which optical objects have not yet been identified, and, secondly, the attempts to extract cosmological information about the origin and evolution of the universe from the statistics of the unidentified sources. More measurements of angular size and source intensity are urgently needed, so that the sources may be classified by their surface brightness, and the statistics of a reasonably homogeneous group of sources can be studied. There are grounds for hope that radio astronomers can provide observations of cosmological significance, but these results have probably still to appear.

The last part of the book is on the theory of solar and cosmic emission mechanisms. There is now wide agreement that most non-thermal cosmic radiation is generated by a synchotron process, in which electrons moving with relativistic speeds suffer accelerations and spiral motion in magnetic fields. One outstanding problem is the connexion between the relativistic electrons and the cosmic-ray flux and its energy distribution. Some workers argue that cosmic rays originate in supernova explosions. Others suggest that the cosmic-ray flux is a manifestation of a universal hot gas from which the galaxies condensed. On this latter theory, radio emission occurs whenever the magnetic field is increased by compression of the gas, which may be due to local cooling, to stellar explosions, or to galactic interactions.

The radio studies of the solar system and of the galactic and extra-galactic radio sources had seemed rather distinct, though one speaker emphasized that they were linked by an incomplete understanding of the mechanisms of emission. Simple extrapolation suggests that the proceedings of a further conference would fill a volume of unmanageable size. Perhaps any future symposium could be divided even more clearly, so that the proceedings could appear in separate, smaller, and less expensive volumes.

This volume is liberally supplied with diagrams, tables and half-tone photographs, and there are very few printers' errors. It will be an extremely useful

and up-to-date reference book and bibliography for all working in radio astronomy, though few will read every paper. It is surely indispensable to all libraries with an astronomical section, and those who can afford private copies will find it very easy to lend to their astronomical friends. H. P. Palmer

MODERN INORGANIC CHEMISTRY

Advances in Inorganic Chemistry and Radiochemistry

Vol. 1. Edited by H. J. Emeléus and A. G. Sharpe. Pp. xi+450. (New York: Academic Press, Inc.; London: Academic Press, Inc. (London), Ltd., 1959.) 12 dollars.

WITHIN the past twenty years inorganic chemistry has recovered from a moribund state to be, with radiochemistry, a fast-growing and extremely active branch of chemical science. Modern inorganic chemistry ranges from physical chemistry and pure radiation chemistry through analytical chemistry to the study of organo-metallic compounds. It is satisfying that this present volume reflects this wide range of interest.

In the first chapter, H. Taube writes on "Mechanisms of Redox Reactions of Simple Chemistry". This chapter is difficult reading for the non-specialist, who is not helped by a lack of clearness of the definitions of the various terms used. However, the actual discussion is extremely clear and contains many details of reactions which the inorganic and analytical chemist tend to think of as simple but which are, as yet, very imperfectly understood. The other chapter of interest to the analytical chemist is on "Activation Analysis", by D. H. F. Atkins and A. A. Smales. This review should be of use to all interested in the determination of microgram and sub-microgram quantities of the elements, but would have been improved by a comprehensive table of the various isotopes and methods used in analysis. Again, on the physical side T. C. Waddington has given an important review of "Lattice Energies and Their Significance in Inorganic Chemistry". The author includes a brief survey of methods of calculation followed by tables of values, many of them newly calculated. G. Harbottle and N. Sutin have written on "The Szilard–Chalmers Reaction in Solids". As an inorganic chemist, I found this chapter disappointing, as the treatment is mainly from a physical point of view and the chemical effects of the Szilard–Chalmers reaction are not dealt with in great detail.

On the structural side, W. N. Lipscomb writes on "Recent Studies of the Boron Hydrides". The order that X-ray crystallography and topological treatment of these and related compounds has brought to this previously intractable subject is one of the most æsthetically satisfying developments in modern inorganic chemistry. W. Rüdorff discusses "Graphite Intercalation Compounds". In view of the extensive use of graphite, often under the most rigorous conditions, in industry the importance of the study of these compounds is clear.

Finally, there are three articles on purely inorganic subjects. "Compounds of Aromatic Ring Systems and Metals" by E. O. Fischer and H. P. Fritz is potentially a most interesting chapter on a field which has only existed for the past eight years. Although factually almost complete, the chapter is disappointing because lack of tabular presentation of the material makes comparison and cross-reference difficult. N. L. Paddock and H. T. Searle write on "The Phosphonitrilic Halides and Their Derivatives". There is currently a very rapid development in the field of inorganic polymer chemistry, and this chapter does full justice to one homologous series. Finally, R. J. Gillespie and E. A. Robinson deal with "The Sulphuric Acid Solvent System". The use and study of non-aqueous solvents is now widespread in inorganic chemistry and this chapter discusses the inorganic applications of what is probably the best understood system.

The volume is extremely well produced and almost free from typographical errors, the omission of all the arrows from one Born–Haber cycle being the most noticeable mistake. My major regret is that the high price will probably mean that it will be purchased only by libraries, and for the complete success of reviews they should be owned by the individual. There is certainly a need for a volume of reviews on inorganic chemistry, and if the editors can obtain articles of the present standard and interest for succeeding volumes the success of the series is assured. D. W. A. Sharp

CLASSICAL CHEMICAL ANALYSIS

Comprehensive Analytical Chemistry

Edited by Prof. Cecil L. Wilson and David W. Wilson. Vol. 1*a*: Classical Analysis. Pp. xi+577. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1959.) 105*s*.

THIS book forms the first part (*a*) of Vol. 1 of Elsevier's "Comprehensive Analytical Chemistry" which is to consist of five distinct volumes, some containing several parts. Vol. 1*a* (to be followed by 1*b* and 1*c*) deals with classical methods of analysis and contains six distinct chapters. Each chapter contains contributions from authorities in particular fields of analytical chemistry and there are, including editorial contributions, a total of nineteen individual authors in the present book.

The subject-matter is essentially of an introductory and general nature which is of importance in all branches of analytical chemistry; but included also are processes of sufficiently long standing that they can come under the general heading of "Classical Analysis. Chapter 1 is the editorial introduction to the entire work. This is followed by a chapter headed "Analytical Processes", which contains sections on materials, sampling, statistics, weighing, measurement of volume, solvent extraction, organic reagents in inorganic analysis, and occupies some 220 pages. Chapter 3 (87 pages) deals exclusively with gas analysis, Chapter 4 (68 pages) with inorganic qualitative analysis, and Chapter 5 (32 pages) with organic qualitative analysis. Chapter 6 (115 pages) treats the subject of inorganic gravimetric analysis.

In the main, this first part lives up to the standard expected from the general title; but in certain sections individual bias has prevented a truly comprehensive presentation of material and this is most marked in the chapters on inorganic and organic qualitative analysis. Here one might reasonably have expected to find a critical account of the various systems and schemes of analysis rather than a detailed

discussion of one preferred system. Fortunately, this does not happen to any such extent in other chapters; in fact, the chapter on gas analysis goes almost to the other extreme and presents the important aspects of the subject in a methodical and critical way.

Altogether, "Comprehensive Analytical Chemistry" has got away to a good start. There are bound to be a number of blemishes in such an ambitious work, but whether these will detract seriously from the value of the completed volumes is scarcely answerable at present. Undoubtedly this will become a standard reference work in analytical chemistry, but like all such extensive publishing projects, there is a considerable danger that, by the time the final volume comes from the press, the earlier volumes will be outdated. The rapid development of new methods and techniques in many branches of analytical chemistry tends to lessen the value of this encyclopædic type of text, except as a means of collecting together the available information at the time of writing. Too often publishing delays result in the presentation of much out-dated material, which the authors and editors are powerless to prevent.

This book has the dubious advantage over four other (to the reviewer's knowledge) similar projects in being first in the field. As such it is bound to come in for a good deal of comment not all of which will be friendly. Nevertheless, on the basis of this first volume, an appreciably high standard has been set for the complete work, and the appearance of the subsequent parts and volumes is awaited with considerable interest. Elsevier are to be congratulated on the fine printing and particularly the binding of this book which, as the series is completed, will add grace to the shelves of many libraries.

WILLIAM I. STEPHEN

ION EXCHANGE

Ion Exchange Resins

By Robert Kunin. Second edition. Pp. xiii+466. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 88*s*. net.

Ion Exchange

A Laboratory Manual. By Dr. J. E. Salmon and D. K. Hale. Pp. vii+136. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1959.) 25*s*.; 5 dollars.

WHEN the first edition of "Ion Exchange Resins" by Kunin and Myers appeared in 1950 it was only the second book on the subject in the English language. Since then, five more such books have appeared. However, only two of these have attempted general treatments of the subject and these two are brief monographs. There is still, therefore, plenty of scope within the covers of a single volume for a full length up-to-date account in English of ion exchange in all its aspects, fundamental and applied. This is what Dr. Kunin has attempted. He has certainly succeeded in considerable measure. The present work is both bigger and better than the first edition. Dr. Kunin's greatest successes are in the chapters on ion exchange application. He has done less well on the fundamental side.

Some of the faults of the first edition are still to be found here: a large number of diagrams, not always very clearly labelled or explained in the text; the occasional full account of older (sometimes obsolete) theories (particularly of ion exchange equilibria) with an inadequate amount of some of the recent work. In dealing with cation exchange kinetics on carboxylic exchangers Dr. Kunin repeats almost verbatim the account given in the first edition. The only reference he quotes in connexion with this topic is some work of Kunin and Barry in 1949. A few papers on this topic have been published since then but no mention is made of them. In particular, he ignores the important theory of Bauman, which many would consider to be at least as plausible as the theory of Kunin and Barry. However, the chapter on the synthesis of ion-exchange resins is a very great improvement on that in the earlier edition and there are excellent chapters on permselective membranes and catalysis with ion-exchange resins. In general, anyone reading the more fundamental parts of this book would be advised to refer also to other books (Kitchener or Griessbach) to check, supplement or correct the impressions gained. However, this book may be recommended as a useful reference work, particularly with regard to ion-exchange applications.

Dr. Salmon and Mr. Hale have broken completely new ground in their book. This splendid little book is an attempt (the first, so far as I know) to teach ion exchange to students by means of a carefully planned series of experiments. The first five chapters form a theoretical introduction to the remainder of the book, which contains the experiments. The discussions of the experiments form a particular feature of the book and they are both clear and stimulating. The authors' statement (p. 116) that "The regeneration of a mixed-bed column is not readily achieved with small laboratory columns" may not command universal assent, and the consequent omission of any account of such regeneration procedures is open to criticism. Indeed, many workers would probably prefer a straightforward mixed-bed column for de-ionization to the three-stage procedure described by the authors. However, these are comparatively minor points which later editions may remedy. This book deserves every success, as it should be useful not only to students but also to all laboratory workers who have anything to do with the practical side of ion exchange.

D. REICHENBERG

GEOCHEMICAL RESEARCH IN THE UNITED STATES

Researches in Geochemistry

Edited by Philip H. Abelson. Pp. x+511. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1959.) 88*s*. net.

THIS book, edited by the Director of the Geophysical Laboratory, Washington, is the outcome of a seminar series in geochemistry organized by the Geophysical Laboratory and held there, and at the Johns Hopkins University, during the academic year 1957–58.

It gives a valuable conspectus of current geochemical research in the United States, and the wide range of topics covered is best indicated by listing the titles of the contributions (authors' names in brackets): sedimentation on the ocean floor (G. O. S. Arrhenius), pp. 1–24; rates of geochemical reactions at low temperatures and pressures (R. M. Garrels),

pp. 25–37; geochemical indicators of marine and fresh-water sediments (M. L. Keith and E. T. Degens), pp. 38–61; geochemical prospecting (H. E. Hawkes), pp. 62–78; geochemistry of organic substances (P. H. Abelson), pp. 79–103; some chemical aspects of petroleum genesis (W. E. Hanson), pp. 104–117; mineral assemblages of the Green River Formation (C. Milton and H. P. Eugster), pp. 118–150; tritium in hydrology and meteorology (W. F. Libby), pp. 151–168; measurement and use of natural radiocarbon (H. de Vries), pp. 169–189; geochronology (G. R. Tilton and G. L. Davies), pp. 190–216; the variation of the $^{18}O/^{16}O$ ratio in Nature and some geological implications (S. Epstein), pp. 217–240; isotopic fractionation of sulphur in geochemical processes (W. U. Ault), pp. 241–259; the use of equilibrium calculations in finding the composition of a magmatic gas phase (K. B. Krauskopf), pp. 260–278; the chemical environment of ore deposition and the problem of low-temperature ore transport (P. B. Barton, Jr.), pp. 279–300; sulphide systems as geological thermometers (G. Kullerud), pp. 301–335; some aspects of the geochemistry of carbonates (J. R. Goldsmith), pp. 336–358; diffraction effects of short-range ordering in layered sequences (F. Chayes), pp. 359–376; hydrothermal investigations of amphiboles (F. R. Boyd), pp. 377–396; reduction and oxidation in metamorphism (H. P. Eugster), pp. 397–426; local equilibrium in metasomatic processes (J. B. Thompson, Jr.), pp. 427–457; activation analysis applied to geochemical problems (G. W. Reed), pp. 458–475; chondrites and the chemical composition of the Earth (G. J. F. MacDonald), pp. 476–494; equations of state and polymorphism at high pressures (S. P. Clark, Jr.), pp. 495–511. Each article has a good selected bibliography, and the book is well produced and printed. It is to be regretted that there is no index.

It would be invidious to single out particular articles where all are of high standard, and it is sufficient to say that this book should be of great interest not only to geochemists wishing to have authoritative accounts of work in fields other than their own but also to geologists in general.

S. R. Nockolds

HETEROCYCLIC CHEMISTRY

Chemistry of Carbon Compounds

A Modern Comprehensive Treatise. Edited by Dr. E. H. Rodd. Vol. 4, Part B: Heterocyclic Compounds. Pp. xviii+809–1464. (Amsterdam: Elsevier Publishing Company; London: D. Van Nostrand Company, Ltd., 1959.) 100*s*.

s-Triazines and Derivatives

By Edwin M. Smolin and Lorence Rapoport. (The Chemistry of Heterocyclic Compounds: a Series of Monographs, Vol. 13.) Pp. xxiv+644. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1959.) 226*s*. net.

BOTH the above works are massive volumes of well over six hundred pages which are packed with detailed information: to give a true review, that is, one which critically assesses the contents and their presentation, of either volume in a short space is therefore almost impossible.

Vol. 4*B* of Rodd's "Chemistry of Carbon Compounds" is an impressive work, in which a uniformly high standard is maintained by the seven contributors. Dr. Neil Campbell has written a considerable chapter on six-membered ring compounds having oxygen and/or sulphur in the ring, thus including in particular pyran, chromen, benzochromens, the corresponding thia-analogues and the many derivatives of each class. He has also contributed a shorter chapter on compounds having two fused five- or six-membered rings with a nitrogen or oxygen atom in each ring. These chapters are divided by an account by Sir Robert Robinson of brazilin and hæmatoxylin: this article by so great an authority makes one deeply regret that Sir Robert has been too busy to make further and fuller contributions to the volume. An excellent chapter on the cyanine and related dyes, giving a necessarily condensed but very clear account of this vast range of fascinating compounds, has been written by Dr. G. de W. Anderson. Dr. T. S. Stevens has contributed a chapter on the indigo group, and another very considerable chapter on the pyrrole pigments, which contains among many other interesting subjects an excellent account of the chemistry of chlorophyll and of vitamin B_{12}. Dr. Stevens has also collaborated with Dr. Ishbel G. M. Campbell in a final chapter on "Compounds containing Unusual Hetero Atoms", that is, silicon, phosphorus, arsenic, antimony, bismuth, halogen and certain metallic atoms. This deals with a section of heterocyclic chemistry which is usually omitted in textbooks, but which is of absorbing interest in its own right, apart from being a refreshing change from nitrogen compounds. It can be strongly recommended as a really modern review of this field. Incidentally, the chemistry of silicon and phosphorus is expanding so rapidly that these elements will soon cease to be 'unusual hetero atoms'.

The editor and the contributors are to be warmly congratulated on this excellent volume, which will so greatly enhance the value of the complete work.

"*s*-Triazines and Derivatives" is the thirteenth volume to appear in the Interscience "Chemistry of Heterocyclic Compounds" Series, which has now become by far the major series to give a modern account of this vast division of organic chemistry. The authors state that the subject-matter of this book was originally intended to be part of a single volume dealing with triazines and tetrazines, but that the immense amount of material necessitated two volumes, the first, on 1,2,3- and 1,2,4-triazines and tetrazines by Drs. Erickson, Wiley and Wystrach, having been recently published as the tenth volume in the series, and this second volume is now devoted to *s*-triazines, including the purely inorganic system *s*-triazaboranes.

This volume deserves to receive a wide welcome, from both academic and technical chemists. Many academic chemists have only a general knowledge of many of the classes of compounds discussed, and should warmly welcome the clear and detailed account here presented: many of these compounds, moreover, are of considerable and steadily increasing technical application, and the volume should therefore also be of great interest to technical chemists. As an example, the chemistry of cyanuric acid, its halides, esters and other derivatives is discussed in a chapter of 120 pages: the treatment ranges from a very full discussion of the physical properties of cyanuric acid to the application of its derivatives in many branches of chemistry such as dyestuffs, pesticides, resins, explosives and also in medicine. Melamine and

*iso*cyanuric acid are two other compounds of considerable theoretical and technical interest, and a chapter is devoted to each compound and its derivatives. Condensed ring *s*-triazine systems, and hexahydro-*s*-triazines also receive a detailed and logical discussion in separate chapters. All the above compounds contain the same six-membered ring system of alternating carbon and nitrogen atoms, usually of considerable stability. The reader therefore may come with some surprise to hexamethylenetetramine, the whole chemistry of which is so different from that of the preceding compounds: this compound does, of course, contain three such rings fused uniquely together, and the full account of its reactions is to be greatly welcomed. Both inorganic and organic chemists will also welcome the final chapter on *s*-triazaboranes.

The author and the publishers may be justly proud of this volume, which will give added strength to the whole Interscience series. The reviewer feels that the chemical public are also indebted to the American Cyanamid Co., which has ensured facilities for the writing of this considerable volume by two members of its staff, and also for the contribution to Vol. 10 by another member, Dr. Wystrach.

F. G. Mann

ENZYMES

Outlines of Enzyme Chemistry

By J. B. Neilands and Paul K. Stumpf. With a Chapter on the Synthesis of Enzymes by Roger Y. Stanier. Second edition, revised and enlarged. Pp. xii+411. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1958.) 68*s*. net.

The Enzymes

Edited by Paul D. Boyer, Henry Lardy and Karl Myrbäck. Vol. 1: Kinetics, Thermodynamics, Mechanism, Basic Properties. Second edition, completely revised. Pp. xiii+785. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1959.) 24 dollars.

THE two books reviewed here deal with the same subject but at a very different level. They are aimed at different readers, but each in its class should prove extremely valuable.

This second edition of "Outlines of Enzyme Chemistry", by Drs. Neilands and Stumpf, has undergone considerable changes and has expanded by about one-third compared with the first edition. It is intended for the beginner and gives a concise and fairly elementary coverage of the whole field of enzymology. Also included is a certain amount of background material which will be very helpful to the student; for example, there is an excellent section on physical chemistry which leads smoothly into the discussion of enzyme kinetics. Some chapters carry the material to a very advanced level, and the book will undoubtedly be useful to many research biochemists as a reference book. A new feature is an alphabetical list of more than five hundred enzymes, with some properties and key references.

A large number of references is given throughout the book, but their selection appears in places to have been rather random. The density of documentation is rather uneven; for example, there are only sixteen references after a chapter on oxidation-reduction, but 136 to a chapter on the classification of coenzymes.

Vol. 1 of "The Enzymes", under the editorship of Boyer, Lardy and Myrbäck, is the first of a series of four volumes to replace Sumner and Myrbäck's "The Enzymes: Chemistry and Mechanism of Action", which since its publication in 1950 has become a classic work of reference. It is not in any real sense a second edition, but a completely new work by new authors, arranged in a different way. As the editors state in the preface, much of the material will be "supplemental to that of the previous edition, and thus the previous edition will continue to serve as a useful reference work in certain areas". The new series will not deal with metabolic relationships, nor will it contain details of methods of preparation, etc., which can be found in the companion treatise, "Methods in Enzymology". The aim is to give a full account of enzymes and enzyme action "on a molecular level".

Vol. 1 is devoted to kinetics, thermodynamics, mechanism and basic properties. It stands on its own, in fact, as a text-book on the fundamental principles of enzymology. There are four excellent chapters on enzyme kinetics, including a historical survey by H. L. Segal and the development of the complete steady-state rate equation by R. A. Alberty. The mechanism of enzyme action is discussed *inter alia* by R. Lumry, D. E. Koshland, P. D. Boyer and H. Fraenkel-Conrat. There is a useful review of structural and stereospecificity by H. Gutfreund. Probably the most difficult chapters are by P. George and J. S. Griffith on "Electron Transfer and Enzyme Catalysis", and by R. J. P. Williams on "Co-ordination, Chelation and Catalysis"; but many enzymologists concerned with oxidation systems will be extremely grateful for these carefully written accounts of relevant fundamental chemistry. Although much of the book is concerned with the fundamental chemistry of enzymes and enzyme action, the final two chapters, on enzyme induction by M. R. Pollock, and on the control of enzyme activity by A. B. Pardee, introduce a more biological note.

There is no doubt in the reviewer's mind that, if the standard of this first volume is maintained, "Boyer, Lardy and Myrbäck" will be a worthy successor to the ubiquitous "Sumner and Myrbäck".

Edwin C. Webb

HUTCHINSON'S 'FAMILIES'

The Families of Flowering Plants

By Dr. J. Hutchinson. Second edition. Vol. 1: Dicotyledons. Pp. xi+510. Vol. 2: Monocotyledons. Pp. viii+511–792. (Oxford: Clarendon Press; London: Oxford University Press, 1959.) 147*s*. net the two volumes.

THIS well-known work by Dr. J. Hutchinson was first published in 1926 (Vol. 1) and 1934 (Vol. 2), and has long been out of print; a second edition, in which the treatment of the dicotyledons has been expanded and greatly altered, has now been produced by the Oxford University Press. This new edition will be welcomed by those interested in changing views about the evolutionary relationships of flowering plants and will be useful to students of taxonomy (if they can afford to buy it).

To begin with, it may be said that Vol. 2 is unaltered except for the addition of one family and of genera which have been described since 1934, so that this review will be concerned mainly with the first volume.

The two most striking innovations in this are the extensive changes in the order of the families and the addition of no fewer than 76 families, not recognized in the first edition. It seems unfortunate, in view of this and of its special interest, that Degeneria even if not accorded family rank should not be given fuller treatment.

Dr. Hutchinson indicated in 1926, and has since emphasized, his belief in the fundamental importance of the difference between the woody and the herbaceous habit in dicotyledons. This view reaches its full expression here, and when combined, as it is, with the rejection of the customary criteria of polypetally and sympetally, leads to a complete rearrangement of families. Opinions will differ about the validity of this basis, but two things are certain: there is at present no means of proving or disproving the truth of Dr. Hutchinson's views, and there is equally no denying that for the general practitioner of angiosperm taxonomy the adoption of the new system would be highly inconvenient.

This, of course, raises once again the question of the purpose of classification, and it appears that here there has been an attempt to achieve two rather incompatible ends.

The first and most important is the exposition of a new and revolutionary system of classification which, Dr. Hutchinson believes, represents phylogenetic relationships and distinguishes them clearly from similarities due to parallel development from different stocks. Here there is, of course, endless room for discussion and for disagreement as well as agreement, but certain difficulties, one might almost say inconsistencies, soon come to light. Why, for example, are the Malvaceae regarded as belonging to Lignosae, except to keep them near the Tiliales? More than half the genera are wholly or partly herbaceous and the wood of many of the others is not particularly hard. The Globulariaceae, placed in Herbaceae, seem much woodier.

The statement of general principles adopted for classification is the same as in the first edition, though some minor revisions might have been expected, notably in the assertion that compound leaves are derived from simple ones. The principles are not always rigorously applied or surely the Compositae would have displaced Labiatae as "the climax development of the fundamentally herbaceous line of evolution".

The second purpose of this work, and one which will be found generally useful, is the concise description of the families recognized and the provision of keys by which an unknown plant can be referred to its family. From the purely practical point of view it seems to me that it would have been more useful to have had this part of the book issued separately and arranged according to one of the better known, though phylogenetically unsatisfying, systems. These systems are fossilized in herbaria, and will remain so, since it is impracticable to rearrange even a moderate-sized herbarium every time views on classification of families change. Every working taxonomist will therefore continue to need an acquaintance with the systems of Bentham and Hooker and of Engler, so time would be saved and convenience increased if Floras and other reference books followed one of them.

If a separation of this kind had been made it might have been possible to devote more space under each family to a discussion of the reasons for the classification.

The book is well produced, as is to be expected from the Oxford University Press, though a few misprints, such as "Buddeciaceae" on p. 101, have got by, and the drawing of what appears to be *Chenopodium capitatum* in Fig. 283 is still unlabelled. More serious is the absence of a number on p. 19, though this page is referred to by number in the text; the omission is doubtless in accordance with the best typographical practice but is annoying when one is trying to look it up. Even worse is the placing of the index to Vol. 1 on pp. 101–103 'for ready reference'. Reference would have been much easier if it had been put at the end of the volume in the usual way, though there is a suggestion on p. 101 that this was intended; if so it was overlooked.

In spite of these drawbacks the book is well worth a place in any botanical library for its iconoclastic treatment of conventional ideas, which should provoke thought and argument, and for the practical value of its keys and descriptions. T. G. Tutin

COCONUTS

The Coconut Palm

A Monograph. By Dr. K. P. V. Menon and Dr. K. M. Pandalai. Pp. xvi+384. (Ernakulam: Indian Central Coconut Committee, 1957.) Rs. 38; 85*s*.; 11.95 dollars.

SOUND monographs on the major crops are always welcome, not only to those with a specialized or professional interest but also to the general reader. A new work on the coconut palm by Dr. K. P. V. Menon, director of the Central Coconut Research Station, Kayangulam, and Dr. K. M. Pandalai, joint director of the Central Research Station, Kasaragod, comes into this category. The volume is published under the auspices of the Indian Central Coconut Committee, Ernakulam, South India.

The coconut palm, sometimes styled the 'Tree of Heaven', is still of unknown origin though the best contemporary opinions are in favour of a location in south-east Asia. It now occurs in littoral regions throughout the Tropics. In those regions, for example, India and Ceylon, where it is grown as a major crop, it not only constitutes the general economic basis but also provides many essential and accessory domestic materials. The nut, it need scarcely be said, is the principal article of commerce. According to the authors, the present position in India is that although there is indeed a vast production of nuts, this is still inadequate, and considerable imports of coconut products from Ceylon, Malaya, etc., are essential. After a bad period in the 1930's and during the Second World War, the industry was in a parlous position. To improve matters, the General Coconut Committee was set up in 1945 to take all necessary measures for the improvement and development of the industry. The present volume is one of the results of this new and important effort.

Several books devoted to the coconut have already been published. In the present work use has been made of them and of other relevant information, the overall effect being that the reader is presented with an unusually full and thoroughly documented account of this crop in its many aspects. The opening chapters are devoted to the origin and importance of the coconut, its general morphology, floral biology,

varieties, breeding and the effect of environmental conditions. The following chapters deal with the production of quality planting materials, field culture, soil conditions, especially in their nutritive aspects, plantation management and yield. Other chapters are devoted to diseases and pests, of which there is no scarcity. There are also interesting and useful chapters on the tapping of the plant for its juice, curiosities or abnormalities in the development of the plant, and the utilization of its many and varied products. In the final chapter, the many outstanding problems in contemporary coconut research are discussed. In attempts to improve the industry, it need scarcely be said that the introduction of varieties and strains, and a considerable breeding programme, occupy an important place.

The book is very fully documented and well illustrated, some of the coloured plates and photographs being of very good quality indeed. It is hard to avoid the impression that research on the coconut palm is by no means as advanced as it ought to be; but what is known is faithfully presented in the volume under review.

C. W. WARDLAW

HORMONES IN CRUSTACEANS

Endocrine Control in Crustaceans

By David B. Carlisle and Sir Francis Knowles, Bart. (Cambridge Monographs on Experimental Biology, No. 10.) Pp. vii+120+5 plates. (Cambridge: At the University Press, 1959.) 21*s*. net.

COMPACT books, along with compact cars, provide a welcome relief in some of the more crowded parts of this world. Limited size, but not this alone, contributes to the popularity of the series of monographs of which "Endocrine Control in Crustaceans" is Number 10. Dealing mainly with developments of the past ten years, this book discusses the phenomenon of neurosecretion and contributions to this relatively new field resulting from studies on the Crustacea. Neurones, modified for secretion, have been found in most animals that have been examined, but their organization into systems and the roles of the neurohormones that these systems produce are best understood in the vertebrates, insects and Crustacea. The last-named have three principal types of neurosecretory systems: the so-called sinus gland system, the post-commissural organ system and the pericardial organ system. In each of these, the neurones end on blood spaces and release their products into the circulation, where they are distributed throughout the body to control a wide variety of physiological processes. In this book one finds a discussion of the anatomy of these systems, including fine structure, and the chemical nature and physiological actions of the hormones that they produce.

Since the sinus glands have been shown to consist of groups of nerve endings, modified for storage and release, only the rather recently described Y organs remain as 'true' endocrine glands in the Crustacea. Their role in the control of moulting and their obvious relation to the prothoracic glands of insects are discussed.

The authors point out some of the confusion that surrounds the identification and naming of components of the X organ-sinus gland system. This arises, in part, from the incomplete evidence that the 'sensory-pore X organ' is an important endocrine structure and the apparent desire on the part of some workers to link one important group of neurosecretory cell bodies of the eyestalk, the medulla terminalis ganglionic X organ, with the original X organ complex of Hanström. This matter and others pertaining to crustacean endocrines will be clarified in the next decade by workers who will find this compact book a most helpful résumé of our current understanding of this field.

J. H. WELSH

RENAISSANCE ANATOMY

A Short Introduction to Anatomy (Isagogae Breves)

By Jacopo Berengario da Carpi. Translated with an Introduction and Historical Notes by L. R. Lind, and with Anatomical Notes by Paul G. Roofe. Pp. xi+227. (Chicago: University of Chicago Press; London: Cambridge University Press, 1959.) 37*s*. 6*d*. net.

JACOPO BARIGAZZI (*c*. 1460–1530), or, as he is traditionally known, Berengario da Carpi, was a near-contemporary of Leonardo da Vinci, whose magnificent amateur exploration of the human body stands in fascinating contrast to the work of this competent but uninspired professional. Berengario was a successful physician among the tough characters of Renaissance Italy. Whatever the merits of his medical practice (he cured Lorenzo de' Medici of a skull wound but Cellini reports that he crippled scores of wealthy syphilitics in Rome), he was vigorous, grasping and unscrupulous. His learning in medicine was of the old fashion rather than the new, and his anatomical nomenclature was full of Arabisms which the humanists were soon to replace by Greek terms. In this and other ways Berengario denotes anatomy in transition from the medieval world to the more modern one of Gunther, Sylvius, Vesalius and other expositors of the genuine Galen.

Nevertheless, Berengario is an important figure in the history of anatomy, one who would have been more significant if the pace had not so rapidly accelerated in the next generation. He was certainly experienced, even though his claim to have dissected hundreds of bodies must refer to autopsies rather than scientific dissections. New discoveries and important corrections of traditional errors are attributed to him, and he seems to have performed some original experiments to study the working of the body. His illustrations, though few, are superior to all preceding ones. If these and his text pale in comparison with those of Vesalius twenty years later, Berengario and others show that the study of anatomy was proceeding actively long before Vesalius took up the scalpel.

Berengario's chief work was a Commentary (1521) on the fourteenth-century anatomy of Mundinus. In the following year he published a shorter compendium ("Isagogae breves") of human anatomy. This has now been translated by Dr. Lind, who ten years ago printed an English version of Vesalius' "Epitome". Berengario writes as a practical guide to dissection; thus the student is instructed: "Leave the left kidney in its place until the spermatic vessels are examined. Cut the right kidney in its hollow through the middle, examining the place of the vein and of the great artery itself. . . ." Anatomy is accompanied by brief remarks on the temperaments, functions and diseases of the structures described. The

approach is direct, and the object the instruction of beginners. Accordingly, Berengario wrote a text lacking all literary charm and speculative interest, which the translator cannot greatly embellish. In fact, Dr. Lind has adhered rather closely to the original, with a result that is stiff and in some places could mislead an unwary reader. A sentence (referring to the chest) such as "The lateral parts are called ribbed and the sides and the region of the breasts" is common enough in Latin but fails to convey any clear meaning in English. Inevitably the translation abounds in technicalities, some those of the modern anatomist, others long disused. It would have been more convenient to the reader (though more troublesome to the printer) to have supplied notes on the page, rather than in two places at the end of the book. From p. 50, for example, there are two notes on the "guidez veins", one (p. 202) by the anatomical annotator Dr. Roofe simply identifying them with the jugulars, and another (p. 185) by the translator explaining the term at greater length. Some of the figures reproduced are very defective and it is not clear whether they are always found in this poor state.

In other respects this volume is handsomely produced and it is very useful to have such a rare and influential work as Berengario's (issued in English as late as 1660, though, of course, seriously out of date by then) made available in a modern translation. It gives a clear notion of the merits and limitations of Renaissance medical science, and one can only wish that the far more sophisticated works of Vesalius and his successors were equally accessible. For this reason Dr. Lind's translation will be valued by scholars and all who have an interest in the development of medicine.

A. R. Hall

EVOLUTION OF BEHAVIOUR

Behavior and Evolution

Edited by Anne Roe and George Gaylord Simpson. Pp. viii+557. (New Haven, Conn.: Yale University Press; London: Oxford University Press, 1958.) 80*s*. net.

SYMPOSIA are very much the fashion; and this is understandable enough since the rate of development of the innumerable divisions and sub-divisions of science has now reached such a pitch that the difficulties encountered by a single author in attempting to synthesize and summarize even a very small field of only one science are almost insuperable. However much we come to depend on abstracting services, reviewing and summarizing journals and the like, we are apt to find ourselves faintly pursuing a rapidly receding objective. Indeed, the rate of movement of some branches of science recalls nothing so much as the recession of the extra-galactic nebulæ —we fear communication will be lost, never again to be re-established.

The volume under review is the outcome of two conferences in which thirty-two well-known biologists participated in the attempt to provide an authoritative report on the significance of behavioural studies for the general picture of animal evolution. Many of the writers refer to the fact that you cannot separate behaviour from the mechanisms of behaviour, and that morphology and the adaptation of structures for particular purposes cannot be divorced from the study of the way in which the animal uses those structures. This means strictly that a volume entitled "Behaviour and Evolution" should cover virtually the whole of zoology, from the palæntological record through genetics, embryology and ecology to ethology and systematics and finally anthropology, ethnology and sociology.

Looked at in this way, it is seen that the subject is one for an encyclopædia or a library rather than a single book. This attempt to cast the net so wide, while it has resulted in the provision of a number of interesting and worth-while chapters, has been detrimental to the book as a unit. Scores of other chapters might well have been written. Thus it is interesting and stimulating to read A. S. Romer on "Phylogeny and Behavior with Special Reference to Vertebrate Evolution", and to learn what is known and what is guessed from the study of structure, of the behaviour of Brontosaurus, the Cephalaspids and other palæontological milestones. But this, after all, is stuff which should be found in the elementary textbook and is of doubtful value as a contribution to a symposium volume. Similar criticisms could be levelled at the chapter on "Food-getting Behaviour" by Marston Bates, on the "Axes of Behavioral Comparison" by Henry Nissen and Carpenter's section on "Territoriality". All are interesting in themselves but all attempt to deal with such a wide and elementary field that the task is an impossible one.

What is in need of modern critical summary is the place of behaviour in relation to genetics, in relation to natural selection and adaptation resulting therefrom, and the contribution of behaviour study to the understanding of such matters as isolating mechanisms and the nature of species and other systematic categories. Taking this more restricted view of the subject, the book has a number of excellent chapters which make very rewarding and sometimes exciting reading. The taxonomic aspects of behaviour study are admirably dealt with in two chapters, one by R. A. Hinde and N. Tinbergen and the other by Ernst Mayr. H. T. Spieth has a stimulating section on "Behaviour and Isolating Mechanisms", showing that while behavioural isolating devices are typically innate, they may also contain important learned elements. A penetrating study of the place of behaviour in adaptation as a result of natural selection is contributed by C. S. Pittendrigh. Here, however, the attempt to synthesize seems to have gone too far. It is argued (1) that all organization is relative and directed towards an end; and (2) that the converse of organization is randomness. From this it follows (3) that everything which is non-random must be directed towards an end; and (4) that complexity, organization and adaptation are in the last analysis recognized by virtue of their non-randomness—both of which statements are surely highly doubtful.

The final section, Part 5, "Evolution and Human Behavior", while containing some most interesting contributions, again falls rather outside any central theme that such a book can have. Simpson, in his introductory essay and his epilogue, makes a valiant effort to pull the whole thing together and produce unity out of diversity, a task beyond even him. I believe a more satisfactory result would have accrued had the contributors been fewer in number, had they had longer in one another's company, and had their discussion (carefully edited and revised) been inserted as links binding the whole together.

W. H. Thorpe

LINEAR OPERATIONS AND CLASSICAL ANALYSIS

Linear Operators

By Nelson Dunford and Jacob T. Schwartz. Part 1: General Theory. (Pure and Applied Mathematics: a Series of Texts and Monographs, Vol. 7.) Pp. xiv+858. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1958.) 165*s*.

THE notion of a linear operator (transformation) is familiar to most mathematicians; but the extremely ramified and elaborate theory of such operators, as presented in the work under review, will come as a surprise to many who have not specialized in this field. Part 1 alone of the two-volume work covers 850 pages, including more than 100 pages of bibliography. However, many different parts of mathematics, particularly hitherto rather isolated branches of classical analysis, are brought together under the strong unifying influence of the theory; and the mathematician who has grown tired of exploring one peak after another may take comfort in coming upon an edifice which acts like an umbrella covering a vast area.

Part 1 presents the topological theory of spaces and operators, and the spectral theory of arbitrary operators (the theory of completely reducible operators is deferred to Part 2). Chapter 1 deals with concepts and results from set theory, topology and algebra, and Chapter 2 with the three basic principles of analysis. These consist of (*a*) the principle of uniform boundedness, which involves the result that the limit of a sequence of continuous linear operations is continuous, (*b*) the interior mapping principle, which asserts that in the case of certain spaces continuous linear mappings map open sets on to open sets, (*c*) the Hahn-Banach theorem, which is concerned with the existence of extensions of a linear functional. Chapter 3 deals with integration and set functions, and Chapter 4 with twenty-eight spaces (mostly Banach) which occur frequently in analysis. These include various sequences and the space of all bounded continuous real or complex functions defined on a normal topological space. The notion of convexity in a general linear space is treated in Chapter 5. It is shown how various classes of linear functionals determine topologies in a linear space, including a weak topology in a Banach space. Special attention is given to the compactness properties and reflexivity of these topologies, and some fixed point theorems are derived. In Chapter 6 linear maps between Banach spaces are studied. The notions of adjoint and projection operators and also weakly compact and compact operators are introduced and the basic properties of the operators are obtained. Representations of classes of operators are given in the spaces of continuous and integrable functions. The concepts and methods of Chapter 7 centre around the idea of the spectrum of an operator. Earlier chapters are concerned with topological aspects of operator theory, but function theoretic and algebraic methods are used in the spectral theory. Perturbation theory covering changes in the spectrum and the resolvent operator is developed, the basic theorem here being due to Rellich. Chapter 8, the last of Part 1, is concerned with applications to semi-groups of operators, functions of an infinitesimal generator, and ergodic theory.

A question one might well ask, following upon the presentation of so much theory is: What does it do? The answer is contained in the large number of graded exercises, which, the authors point out, are not 'drill' problems but carrying on the text. In fact, they present the applications of the theory to familiar branches of classical analysis, including summability of series (Chapter 2) and integrals (Chapter 4), orthogonal expansions, particularly Fourier series (Chapter 5), and inequalities (Chapter 6). It is interesting to note, and indicative of the power of the theory, that convexity methods, depending largely on the Reisz convexity theorem, may be used to derive many of the most familiar and important inequalities of analysis.

"Linear Operators" is encyclopædic in character and will probably become the standard reference text in its field. Parts of it may also be used in courses for both undergraduates and those entering upon research. In a work of this size material tends to become buried; but there is a detailed subject index which will help to prevent this and the "Notes and Remarks" at the end of each chapter form a very good guide to the extensive literature.

L. S. GODDARD

MATHEMATICS AND OPERATIONS RESEARCH

Mathematical Methods of Operations Research

By Thomas L. Saaty. Pp. xi+421. (London: McGraw-Hill Publishing Company, Ltd., 1959.) 77*s*. 6*d*.

OPERATIONS research, which is now generally regarded as a well-defined field of activity moving in its own right, began life in unusual circumstances. The impact of war produced many practical problems, both tactical and strategic, which had to be solved, often within a limited time and with a limited amount of information as data. Men, whose basic training had been in different scientific fields, were put together in teams and their task was to formulate and solve the problems inherent in the practical situations at hand. The result was highly successful, and thus operations research was born. In the post-war years activity has developed greatly on the industrial side. In addition, there has been time for a mathematical penetration of the subject to occur, and the use of mathematics in this field forms the subject-matter of the book under review.

There are four parts, the first being a discussion of a varied collection of topics, including scientific method, logic, and the building of mathematical models. Parts 2 and 3 deal with the more serious mathematical methods of operational research, and cover optimization and programming (both linear and quadratic), the theory of games, probability, statistics and the theory of queueing. These two parts form the core of the book and take up about three-quarters of the volume. They are well written and will give the graduate mathematician a good introduction to operational research problems and the sort of mathematical methods needed in their solution. The chapter on queueing is an excellent summary, and it is a pity that it has not been expanded to deal with the subject more fully. One printing error has been detected: on p. 340 the

exponent of μ/λ in the second term of the expression for $P_n(t)$ should be $-n-1$ and not $-n+1$.

The fourth part of the book will probably be a surprise to most readers. It is an essay entitled "Some Thoughts on Creativity". As the title may suggest, it is largely concerned with the psychology of personality and motivation; creativity, in fact, is defined as "the element of the human personality which provides direction". To the reviewer the essay has proved disappointing, and it seems out of place in a book on mathematical methods. The author remarks that "it is difficult to write about general creativity" but has included the essay because it was successful in teaching. It would almost certainly increase the value of the book if, in a future edition, the essay were replaced by, for example, a more extended treatment of queueing or production and inventory problems. In spite of these remarks, the book should prove valuable both to mathematicians who wish to take up operational research and to industrialists who wish to read something of what operational research can do and how mathematics is becoming more and more an indispensable tool in this field.

L. S. Goddard

MECHANICAL IMPEDANCE METHODS IN VIBRATION

Colloquium on Mechanical Impedance Methods for Mechanical Vibrations

Presented at the ASME Annual Meeting, New York, N.Y., December 2, 1958. Edited by R. Plunkett. (Sponsored by Shock and Vibrating Committee: Applied Mechanics Division.) Pp. vi+145. (New York: The American Society of Mechanical Engineers, 1958.) 5.50 dollars.

THE basic theory of linear mechanical vibration has been in existence for many years. Unfortunately, in some respects that theory is not in a convenient form for use in modern vibration analysis. Much effort has therefore been put into re-casting, tabulating, re-examining and extending the known results of vibration theory. It has been found very useful in doing this to borrow ideas which have been developed by electrical engineers for use with a.c. circuits. Although it was realized at the beginning of the century[1] that there is such a thing as 'mechanical impedance', the great practical importance of the idea has only become apparent within the past twenty years.

There are several ways of developing impedance techniques. One may either relate harmonic displacements to a harmonic input force or, alternatively, one may relate velocities to the force; some workers prefer to think of accelerations in terms of harmonic forces. In addition, there is the possibility of measuring the displacement (velocity, or acceleration) per unit amplitude of force or of measuring forces per unit displacement (velocity, or acceleration). The upshot is that several schools of thought have come into being. Few authors (if any) are prepared to think in terms of more than one of these concepts and consequently the literature is becoming difficult, to say the least.

The existence of this rather unsatisfactory state of affairs was the reason for my interest on receiving this work. For it is high time that some body such as the American Society of Mechanical Engineers (which sponsored the publication) set about straightening things out. Unfortunately, the book fails to do this, although its avowed purpose is "to present the state of the art of impedance methods . . . (by presenting) . . . a survey of what has been accomplished to date".

This book contains a dozen papers, most of which have a good deal of technical interest over a fairly narrow range of the general subject of vibration. But there is no attempt to organize the methods used, and indeed more techniques than one are employed in the book. I believe that much of this book will be of real interest to practitioners; it will be found wanting by those who are not primarily concerned with specific aspects of vibration analysis but who want to know what impedance methods have to offer.

At the risk of confusing the issues still further, I would like to make certain comments on the general subject of impedance methods in vibration theory. In the first place, it seems evident that both velocity and displacement techniques are of real practical value. Moreover, it is true that, at least to some extent, it is a matter of taste which is adopted. (What seems much more debatable is whether one should work with displacement (or velocity) per unit force or force per unit displacement (or velocity)—'admittance' or 'impedance', so to speak.) The case for working with acceleration appears to be rather weak.

The late H. G. Yates[2] showed that there are physical reasons for describing the vibratory behaviour of systems in terms of velocity of vibration. Incidentally, credit for this is not given in the book although it is a vital contribution in support of the use of the velocity measurements which are favoured by the majority of the contributors.

There also appears to be an advantage in using velocity calculations and measurements where high frequencies are concerned (say, more than 500 c./s.). High-frequency problems are encountered at the boundary between mechanical vibration and acoustics. A great deal of work is being done nowadays on the silencing of machinery in submarines, and here is an excellent example of where impedance methods may very well be superior; this is because of the requirements of acoustical theory, where power transmission must be considered.

Many workers advance the existence of an analogy between mechanical systems and a.c. circuits as being a fundamental reason for using velocities. For, by so doing, one preserves the analogy. This argument is not as powerful as it may seem, however, since the ability to construct an electrical analogue of a mechanical system implies that the mechanical system is a completely known one. Mechanical systems are usually far less tractable than ordinary low-frequency a.c. circuits. But, here again, the velocity approach does come into its own where compound systems, embodying mechanical and electrical components, are concerned.

The claims which may be made for displacement methods completely outweigh those for velocity, however, at low frequencies in the vast majority of vibration problems. At least this is my opinion. For one thing, it is unnatural to think in terms of a fluctuating velocity rather than a fluctuating displacement. Physical insight is absolutely vital in the solution of practical vibration problems. This is reflected in the book under review in a rather remarkable way; there is no discussion of dynamic

instability although this is an obvious field for use of the displacement approach[3].

Another shortcoming of velocities is that they are not as convenient for use in conjunction with Lagrange's equations. The matrix equation:

$$\mathbf{A}\ddot{\mathbf{q}} + \mathbf{B}\dot{\mathbf{q}} + \mathbf{C}\mathbf{q} = \Phi e^{\lambda t}$$

relating to a system having n degrees of freedom has to be expressed as a form of integral equation if it is couched in terms of generalized velocities (**A**, **B** and **C** are the square inertia, damping and stiffness matrices, respectively, **q** is a column matrix of generalized displacement and Φ is a column matrix representing amplitudes of generalized applied forces, λ being a complex constant). Some idea of the sheer power of the displacement approach may be had from Duncan's pioneering work[3], much of which has no counterpart in the literature as it relates to the velocity outlook.

To be sure, the choice between these techniques is to some extent—perhaps largely—a matter of taste. But to regard this as being entirely a matter of taste would be obtuse. A critical appraisal of the present position, particularly in the light of recent work in automatic control, is still highly desirable.

R. E. D. Bishop

[1] Greenhill, Sir George, "Notes on Dynamics", 78 (London: H.M. Stationery Office, 1908).
[2] Yates, H. G., *Trans. N.E. Coast Inst. Eng. and Shipb.*, **65**, 225 (1949).
[3] Duncan, W. J., *R. and M.*, 2000 (1947).

FRICTION IN TEXTILES

Friction in Textiles

By Dr. H. G. Howell, K. W. Mieszkis and Dr. D. Tabor. Pp. xii+263. (London: Butterworths Scientific Publications; New York: Textile Book Publishers, Inc., 1959. Published in association with the Textile Institute.) 42*s*.

In a traditional industry, such as the textile industry, practice has been and, in many aspects still is, ahead of theory. This situation has arisen because able men have had an abundance of time to solve technical problems empirically. During the past few decades, however, a host of new problems has been presented to the textile industry. These problems arise from three main factors: the advent of man-made fibres, in both continuous filament and staple form, the increasing cost of labour and the increasing emphasis on, and uniformity of, quality. The consequences of these changes are the introduction into the industry of high-speed machinery, of control instruments and of an increasing number of scientifically trained men. The Textile Institute is therefore to be congratulated for encouraging the publication, in association with the publishers, of books which relate textile technology to the background of scientific knowledge.

The first result of this association is the publication of the book "Friction in Textiles". This book is in three sections; the first one is a readable summary of current views on friction, in which the limitations as well as the successes of current theory are given a just emphasis. The second part, entitled "Friction in Textile Processing", contains an account of the special frictional properties of wool, followed by chapters on the importance of friction in the different processes through which fibre passes on its way to the finished cloth. It is a measure of the current state of knowledge that all the textile processes can be dealt with in less than sixty pages, compared with twenty-one on the frictional properties of wool and about seventy in the third section of the book, on methods of test.

Scientifically and technologically, the middle section of the book is least successful. Its value, however, is probably greater for the textile technologist than that of the first and last sections, because it represents a brave attempt to give a coherent account, based on the little data available, of a dominant factor in textile processing, namely, friction. The reviewer hopes that textile scientists will read this and be stimulated to carry out the research which is so clearly necessary.

ADVANCEMENTS IN METALLURGY

Constitution of Binary Alloys

By Dr. Max Hansen. Second edition prepared with the co-operation of Dr. Kurt Anderko. (Metallurgy and Metallurgical Engineering Series.) Pp. xix+1305. (London: McGraw-Hill Publishing Company, Ltd., 1958.) 252*s*.

Metallurgical Thermochemistry

By Dr. O. Kubaschewski and E. Ll. Evans. (International Series of Monographs on Metal Physics and Physical Metallurgy, Vol. 1.) Pp. xiv+426. (London and New York: Pergamon Press, 1958.) 63*s*. net.

Vacancies and Other Point Defects in Metals and Alloys

A Symposium organized by the Institute of Metals and held at the Atomic Energy Research Establishment, Harwell, Berks., on 10 December 1957. (Institute of Metals Monograph and Report Series, No. 23.) Pp. iii+234+16 plates. (London: Institute of Metals, 1958.) 40*s*.; 6 dollars.

Vacuum Metallurgy

Lectures presented during the course on Vacuum Metallurgy sponsored by the Department of Metallurgical Engineering in co-operation with the Office of Special Service to Business and Industry, New York University, New York, June 10–14, 1957. (Materials Technology Series.) Pp. xviii+472. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1958.) 100*s*. net.

A Dictionary of Metallurgy

By Dr. A. D. Merriman. Pp. xv+401. (London: Macdonald and Evans, Ltd., 1958.) 126*s*.

The rate of growth of metallurgical knowledge and experience is resulting in a flow of publications covering many diverse fields from many countries and, it must be admitted, of widely differing quality. The five books here reviewed are, however, valuable contributions to their own fields of science or technology.

The first German edition of Dr. Hansen's "Constitution of Binary Alloys" was published in 1936, and immediately gained for itself an honourable place in all laboratories where work on metallic alloy systems was being pursued. With the passage of years this edition became progressively less complete and this new and up-to-date one is, therefore, most

welcome. This second edition is in many respects a completely new work; the text is now in English; the diagrams themselves are plotted on a linear scale of atomic per cent with a non-linear weight per cent scale at the top and the layout of the text is such as to direct the reader to the original literature. As before, the diagrams are compiled from what the authors regard as the most reliable work available and regions of uncertainty are denoted by broken lines. More attention is given to structural details and reference is made to lattice spacing investigations. In its new form this is a quite outstanding publication.

Dr. Kubaschewski's "Metallurgical Thermochemistry" is in its third edition, and is a book which has clearly filled a real gap in scientific literature, appearing only three years after the second. This in itself is sufficient evidence of its quality. It is now firmly established as a standard work, and it is pleasing to note the critical assessment which is its characteristic feature. A few alterations in matters of detail have been made to the text of the second edition, and the tables have again been brought up to date.

The symposium, "Vacancies and Other Point Defects in Metals and Alloys", is notable for two very distinguished contributions, first a paper by Prof. A. H. Cottrell on "Point Defects and the Mechanical Properties of Metals and Alloys at Low Temperatures," and secondly, one by Dr. D. McLean on "Point Defects and the Mechanical Properties of Metals and Alloys at High Temperatures". Dr. T. Broom and Mr. R. K. Ham review the effect of lattice defects as revealed by studies of deformation and annealing experiments, particularly in relation to stored energy and electrical resistance measurements. Dr. W. M. Lomer gives an elegant review of the defect aspects of solid state diffusion; Dr. P. L. Pratt contributes an account of defects in relation to the mechanical properties of ionic crystals and Mr. E. C. Williams and Mr. P. C. S. Hayfield, in what is possibly the least satisfactory contribution, attempt an analysis of surface oxidation processes. The discussion of a rather general character is printed in full with illustrations.

In 1957, the University of New York organized a symposium on "Vacuum Metallurgy", the twenty-eight papers presented at which are now published. The authors, from Europe and the Soviet Union, as well as from America, have covered a very wide field and the importance which vacuum techniques have assumed is abundantly demonstrated. It will, for example, come as a surprise to many readers to learn that masses of steel 150 tons in weight are now subjected to such treatment. That the newer metals titanium, zirconium, etc., which little more than a decade ago were laboratory curiosities, are now fully fledged engineering materials must in the main be credited to the successful application of vacuum technology. On the economic plane, too, it must not be overlooked that, expensive as such techniques are, a vacuum is at times not only the best but may also be the least expensive 'atmosphere' that may be used. The scope of the individual contributions includes vacuum equipment and the thermodynamic and kinetic aspects of the subject; melting processes (including a later addition of a paper on electron bombardment melting); degassing in both the liquid and solid states; distillation and other metallurgical applications. Special analytical techniques may be required, especially for gaseous impurities, and these are considered, while the final chapter is an attempt to foresee future trends. There is an extensive bibliography and an adequate index. In assessing this important book, and the adjective is not undeserved, credit should be clearly given to the editor, who has done his job very well indeed.

The work required in the production of "A Dictionary of Metallurgy" must have been immense, and although it is, as its name implies, a dictionary and not an encyclopædia, it will be a valuable book of reference on many bookshelves. The field of metallurgy is now very wide indeed, and its divisions so diverse, that no one can hope to be conversant with them all. Questions outside one's own range of knowledge must at times crop up and such a source of reference as this has, therefore, a value even to a metallurgist of considerable experience. To those less well versed in the science and technology of metals it should be even more useful.

F. C. Thompson

NUCLEAR ENERGY AND MEDICINE

Medical Sciences

Vol. 2. Edited by J. C. Bugher, J. Coursaget and J. F. Loutit. (Progress in Nuclear Energy, Series 7.) Pp. viii+288+xii. (London and New York: Pergamon Press, 1959.) 105*s*. net.

Advances in Biological and Medical Physics

Vol. 6. Edited by Cornelius A. Tobias and John H. Lawrence. Pp. ix+639. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1959.) 16.50 dollars.

THE first of these books presents selected papers from the sessions relating to the medical sciences of the Second International Conference on the Peaceful Uses of Atomic Energy held in Geneva in September 1958. The selection has been made mainly from the sessions on radiological protection and the second session on the uses of isotopes in medicine. The sessions on biology, physiology and biochemistry are covered by a separate volume.

The papers included in this volume may be divided broadly into three groups. First there are papers which will be chiefly of interest to health physicists, including two papers on the protection of workers in industrial establishments handling nuclear fuels, with other papers on the detection of ingested isotopes by external γ-ray spectrometry, and on the detection of plutonium in wounds and on the treatment of cases of plutonium ingestion. There are also two papers on the metabolism of cæsium-137 and strontium-90.

The second group of papers is of more general interest. One deals with the lack of any measureable difference in life expectancy of radiologists in Britain and comparable groups of people not occupied in radiological procedures. Another concerns the distribution in the incidence of bone tumours in North America in relation to the level of natural radiation, and a third paper deals with the radiation dose required to produce bone tumours, in so far as this can be determined in humans following radiotherapy and also from work with experimental animals.

The final group is of more direct medical interest, dealing with various aspects of radiotherapy, including papers on neutron capture therapy, on the use of cyclotron-produced heavy charged particles, as well as on various techniques using γ-ray sources. In

addition, there is a paper on the mitigation of radiation effects in patients by leukocyte and thrombocyte transfusions and also one on new developments in radiation protection and recovery in experimental animals.

The papers selected bear out the opinion of the editors that although few radical advances have occurred in this field since the previous Conference, there has been considerably more thought put into the subjects. It is unlikely that the reader will be interested in all the papers presented, but the book as a whole does reflect one aspect of this Conference.

The second of these books is the latest volume in this series, published yearly, presenting various topics by leading experts in the fields covered. The previous high standard of the series has been maintained and some of the chapters are very good indeed, particularly those of the review type such as : the effects of ionizing radiation on tumours in experimental animals, by O. C. A. Scott ; ion and water transport in the stomach and intestine, by R. P. Durbin, P. F. Curran and A. K. Solomon ; and isotopic tracers in the study of diabetes, by S. A. Berson and R. S. Yalow. A real attempt has been made by the writers to present these topics clearly and in a straightforward manner. Other chapters deal with methods for increasing radiological contrast, radiobiological aspects of the induction of lysogenic bacteria to produce phage, physical and chemical mechanisms of cell injury by ionizing radiation, artificial and induced periodicity in living cells, microspectroscopy of cells, measurement of the regional circulation in the nervous system using a radioactive inert gas, the effect of ultrasound on the nervous system and a very mathematical presentation of the application of light scattering to biological systems.

The inclusion of a chapter on fall-out from nuclear explosions which is of such concern nowadays does not achieve the same standard as most of the other chapters. The actual mechanism of long-range fall-out over the surface of the Earth, which is now beginning to be understood, receives little attention. In considering the biological hazard the author has not succeeded in clarifying this confused and much debated question.

The book will be of greatest value in a library where it is available to readers interested in the twelve very different topics covered, but the individual reader may well find the book worth buying for the sake of the wider review articles alone.

N. M. Blackett

DERBYSHIRE PLACE-NAMES

The Place-Names of Derbyshire

By Kenneth Cameron. Part 1 : Introduction, River-Names, etc., High Peak Hundred. Pp. lxxiv+1–186. Part 2 : Scarsdale Hundred, Wirksworth Hundred, Morleyston and Litchurch Hundred. Pp. vi+187–514. Part 3 : Appletree Hundred, Repton and Gresley Hundred, Analyses, Index. Pp. viii+515–829. (English Place-Name Society, Vols. 27, 28 and 29.) (Cambridge : At the University Press, 1959.) 35*s*. net each volume.

THIRTY-FIVE years ago the English Place-Name Society published its first introductory volume and thereby began its great task of recording and interpreting the place-names of England. With the appearance of "The Place-Names of Derbyshire" it has now published the material for twenty counties.

In Part 1 of this three-volume work, Dr. Cameron begins with a most interesting introductory essay which shows how place-names may be used to help reconstruct the process and progress of settlement from Roman times onwards. Thus, for example, we learn that "A small and remarkable group of [four] names . . . indicates that men of Irish–Norwegian descent also settled in the county". The two places named Ireton both mean "the farm of the Irishman or Irishmen" and contain as a first element the ON *Íri*, the term used of a Viking who had been in Ireland before coming to England or of Irishmen who accompanied the Vikings to England : of the two other names in this group, "Mammerton has, as its first element, a Goidelic personal name *Maelmuire*, and Mercaston, a British name *Merchiaun* found in north-west England". Similarly, Dr. Cameron also shows that elsewhere the Scandinavian settlers in Derbyshire were mainly of Danish rather than of Norwegian origin.

This place-name evidence is clearly of great importance, and it is therefore all the more unfortunate that the six distribution maps of selected place-name elements do not adequately support the text because relevant detail is often omitted, as the map of certain woodland elements shows. "The former heavily wooded nature of parts of the county, and the almost complete absence of woodland in others, is indicated in a striking way by the distribution of . . . place-name elements . . . which are descriptive, either of the woods themselves, or of settlements in woodland". The subsequent elaboration of this statement quite rightly relates the former distribution of woodland to relief and geology— how much more revealing would the map have been if, besides four place-name elements and the main rivers, it had also included a few selected contours and the outcrops of the Carboniferous and Magnesian Limestone and the Millstone Grit.

Most of the remainder of Part 1, all of Part 2 and the first half of Part 3 contain the details of the individual names arranged first according to hundreds, then within each hundred in alphabetical order of parishes, and within each parish the more important names first followed by minor names and field-names. The extensive use of abbreviations within this section has allowed a tremendous amount of information to be packed into a relatively small compass, and by making frequent reference to the detailed account of the elements to be found in the separate volumes on place-name elements (English Place-Name Society, Vols. 25 and 26) still more space has been saved. It is unfortunate, however, that, especially with minor and field-names, it has all too often been found necessary to omit any explanation of the meaning of the name. For example, of the twenty-five minor names included for the parish of Totley, no explanation is given for a third of these.

The second half of Part 3 contains interesting and valuable analyses both of the elements found in Derbyshire place-names and of the different types of names themselves, and these are followed by two comprehensive indexes covering the material in all three volumes.

Despite minor blemishes, the work is a monument of patient scholarship and, to all interested in Derbyshire and in place-names, these volumes are indispensable.

I. S. Maxwell

A PHYSICAL BASIS FOR LAND USE POLICY IN TROPICAL CATCHMENT AREAS

By Dr. H. C. PEREIRA

East African Agriculture and Forestry Research Organisation, Muguga, Kenya

THE rapid rise in the standard of living of much of the world's population over the past few decades has caused many countries to give anxious consideration to their future water supplies. Even in Great Britain the problems of water supply and demand are requiring increasing attention[1]. In comparison with the advance of science in other fields the techniques for the study of the water relationships of catchment areas are somewhat undeveloped. In the United Kingdom there is much controversy about the hydrological effects of the afforestation of the hillsides the run-off of which supplies the big cities. In middle-western States of America the management of natural forests which cover the mountain catchment areas has been the subject of fierce controversy between irrigation, grazing and timber interests.

In the high-altitude tropics the development of the forested high ground for production of softwoods and other valuable plantation crops gives rise to similar problems which face the modern administrator with difficult decisions. Established facts and techniques are scarce. Moreover, they have been derived in a variety of geographical environments and involve many scientific and technological disciplines. As a result, trenchant arguments by specialists concerned with limited aspects of these problems cause confusion, and there is growing public concern at the rate at which cities in many countries are outgrowing their traditional water supplies.

The basic climatic factors of amount, intensity and seasonal distribution of rainfall, together with the amount and seasonal distribution of evaporation, set the boundaries to these problems. Although this is an elementary statement of fact these boundaries are often ignored in arguments seeking to apply findings in one country to problems in another. The physical principles are relatively simple. The routes by which rainfall, arriving in excess of the prevailing evaporation rates, can reach a stream are classified by hydrological analysts into three categories: immediate overland run-off, delayed subsurface flow through the porous soil of the plant root zone, and ground-water flow from porous aquifers beyond the depth of plant roots.

The relative importance of these three routes by which rainfall becomes stream-flow is determined by the character of the rainfall distribution. In mild climates of well-distributed rainfall, the overland route may be entirely acceptable. It is, for example, the principal means of filling many reservoirs in the United Kingdom, where shallow-soiled catchments are, under well-managed sheep pasture, capable of delivering clean run-off water. Where reservoir capacity is adequate, infiltration can then be of secondary importance, so that heavily grazed pasture can be a satisfactory catchment area cover.

In the colder climates the hydrological performance of mountainous catchments may be dominated by the trapping and storing of snow and by its rate of melting, so that forest management practices become of dominant importance. Reservoirs of high capacity are necessary to avoid loss of the snow-melt flood-water which is confined by frozen subsoil to the overland and sub-surface routes.

The high-altitude tropics of Africa present a contrasting set of problems. Here few of the newly developing communities can afford the very large structures which would be required to store overland flow from the strongly seasonal rainfall. Here also the high rainfall intensities cause destructive acceleration of erosion wherever run-off is unchecked. Overland flow is thus an entirely unacceptable route, and infiltration is the critical factor for the continuity of water supplies throughout the dry seasons. These supplies must depend upon the seasonal recharge of the ground-water reservoirs which maintain spring-flow. Fortunately, tropical weathering has produced soils which are very deep and characteristically porous, so that, provided the land use is controlled to secure the maintenance of high infiltration rates at the soil surface, the dry-weather flow can be sustained.

These conditions apply throughout most of British East Africa, where the over-riding technical consideration in determining land-use policy for a catchment area must be the maintenance of dry-weather stream-flow. Where political considerations, shortage of technical staff, or plain administrative weakness has permitted gross violation of this principle, with consequent destruction of soil resources by over-grazing or by primitive cultivation methods, this is now known beyond doubt to be a short-sighted policy which will impoverish future African generations.

Where man has not destroyed it, a continuous canopy of forest covers most of the important high-rainfall catchment areas of tropical Africa within which the major permanent streams arise. Determination of the optimum land-use policy for these catchment areas poses two main questions of principle. First, is the natural forest the most efficient catchment-area vegetation from the criterion of dry-weather stream-flow? Secondly, since these well-watered areas of deep fertile soil can be, under modern plantation techniques, among the most productive in Africa, can they also be successfully managed for both stream-flow and agriculture or plantation forestry? Where territorial income depends primarily on agriculture and forestry, the first priorities for investigation must be the most productive forms of land use.

Studies of the performance of large catchments under mixed forms of land use have been shown in the United States to yield relatively little precise information, even when continued over many years. To be fully effective, this type of research must comprise intensive measurements of the water cycle during controlled land-use changes on complete catchments, and continuous comparison with adja-

cent unchanged control catchments. If the new land usage is to increase the productive wealth of the territory, then substantial investment of capital and the application of commercial skill and experience are necessary, either through private enterprise or State development. This places such schemes beyond the usual resources of the specialist research worker, and indeed the urgency for correct solution of these catchment area problems necessitates the support and active interest of governments at ministerial level.

The immediate questions asked by responsible administrators must be: "What will it cost?" and "How long will it take?" Experience in British East Africa at present suggests that the costs can be kept very low by combining development of either government or private large-scale enterprises with research into their effects. Most of the rich forested catchments are already under Forest Reserve or Crown Land protection, and release of the necessary areas for experimental land-use changes can be made contingent on the preservation of control valleys and the maintenance of agreed schedules for clearing and development.

These problems can be solved only by combining the scientific knowledge and experience of agricultural and meteorological physicists, hydrological and soil conservation engineers, foresters, geologists, agronomists, topographical and soil surveyors, and particularly in Africa, by the active co-operation of the administrative authorities. The research itself needs only a small team of full-time workers with whom the many technical officers of government departments and of commercial enterprises can co-operate. The urgent need that factual information about changes in water regimes should be won while the choice of land-use alternatives can still be made is best appreciated by those most actively concerned with the development of Africa; the ready co-operation of the more enlightened administrators, together with their technical advisers, is therefore the rule rather than the exception.

The length of time required to secure a reliable result has, in the past, been a main obstacle to the initiation of this type of research. The 'classical' method has been to compare annual stream-flows of pairs of valleys over periods of 10–20 years, in order to provide a statistical basis for subsequent study of a land-use change on one of each pair. Since a similar run of years is then needed under the new land use, the time required is inappropriate to countries which have already crowded into fifty years the developments which took centuries in the older temperate-zone communities. The classical method is also vulnerable to those extreme spells of departures from average rainfall which can occur by chance without postulation of weather cycles. Kerrich[2] has illustrated how successive departures from the average occur by chance in genuinely random data.

Fortunately we have most favourable combinations of meteorological and geographical circumstances in the high-altitude tropics which offer facilities for measurement which are unmatched in temperate zone hydrology. Our freely drained uniform stone-free soils, usually ascribed to the effects of Pluvial era leaching, have astonishing depths ranging from 10 to 60 ft. on many major catchment areas. They are underlain, in a few selected areas, by impermeable lava flows. Strongly marked wet and dry seasons ensure the substantial depletion and recharge of the soil within the root ranges of forest, pasture or crops. These changes are readily followed by occasional extensive deep samplings, linked by the records of electrical resistance tensiometers; they thus afford unique opportunities for the direct measurement of evapotranspiration. Based on these periods of direct measurement, the energy balance method of Penman, which has solved the hydrological balance for many catchments in the United Kingdom[3], extends the numerical estimate of evapotranspiration to the complete water year. Fully equipped meteorological stations, including radiation measurements, are therefore operated on the site of each experiment. The seasonal totals of rainfall, evapotranspiration and stream-flow are thus obtained independently, and the hydrological balance is completed by the measured water storage changes in the first 10 ft. of soil, within which the major seasonal depletions occur. Changes in the ground-water storage, between the 10 ft. depth and the stream, are calculated from the running water budget of the first 10 ft.[4] and the measured stream-flow.

These favourable circumstances afford opportunities for earlier information on changes in water regimes, the time required to obtain results depending mainly on the rate of development of the new form of land use. Mechanical equipment, backed by the large and well-organized labour forces of modern plantation industries, can ensure rapid development[5]. Growth-rates, moreover, are high in the tropics so that pastures, tea, coffee, cocoa or softwood plantations rapidly establish their canopies and root ranges, by which their main hydrological effects are achieved. In the arboretum of the East African Agriculture and Forestry Research Organization, for example, 6 species of *Eucalyptus* have grown more than 40 ft. tall and 5 in. in diameter in four years after planting[6]. A pasture grass, *Cynodon dactylon*, planted from splits on 8 acres of fallow soil containing 12 replicate profile sets of electrical resistance tensiometers developed roots to a depth of 10 ft. in 12 months and heavily depleted the soil moisture to this depth[7].

Four co-operative inter-departmental studies based on these methods are in progress in British East Africa. The land-use changes under study are: first, the conversion of indigenous bamboo forest to soft-wood plantations in the catchment areas of the Aberdare Mountains, from which the city of Nairobi draws its water supplies for a quarter of a million inhabitants; secondly, the conversion of indigenous tall rain forest to tea plantations in an area from which the streams supply a well-developed existing tea industry and a large area of African peasant agriculture[8]; thirdly, the effects of the opening and closing phases of shifting peasant agriculture in steep mountain valleys as compared with the indigenous forest cover; fourthly, the conversion of over-grazed thornscrub to rotationally grazed pasture, in semi-arid catchments which at present produce only torrent flow.

Only stencilled progress reports have as yet been issued; but detailed analyses of the data of the first two years are now being prepared for publication.

These show similar behaviour from dense 40 ft. high bamboo forest on the Kinangop Mountain on the Aberdares (lat. 0° 45′ S.) and from heavy 100 ft. high rain forest on Sitoten Mountain in the Lake Victoria catchment (lat. 0° 20′ S.). Both are at altitudes near 8,000 ft. and receive 70 in. or more of total annual rainfall. In each case infiltration rates are equal to those of the heaviest storms, and no

surface run-off is perceptible. The first 10 ft. of deep porous soil remain continuously wet and evapotranspiration remains at or very near full potential. Measurements so far indicate that evapotranspiration rates approach, and are at times fully equal to, those of open water. These wet forested valleys are hydrologically more similar to lakes than to usual land surfaces. The stream-flow yields differ as a result of the very different ratios of rainfall to evaporation rates, varying from annual totals of 15 per cent of rainfall in the warmest of the valleys to 56 per cent of rainfall in the coolest.

In the warmest of these forests, where evaporation is more than 55 in. per annum, the soil moisture tension throughout the first 10 ft. depth has remained below 1 atmosphere for the 2 years of observations. Tension-plate and pressure-plate measurements on undisturbed soil cores have shown a total storage capacity of 20 in. of available water in this depth, but periodic sampling has shown that moisture deficits have not yet exceeded 10 in. The fluctuations in soil moisture storage have equalled the total annual stream-flow from this 1,750 acre valley, which indicates the importance of the quantitative soil moisture budget[4] in the water cycle. An example of the favourable nature of these soils for water measurement is given in Table 1, which compares the moisture contents found by periodic sampling under 'field capacity' conditions with the laboratory determinations made on undisturbed soil cores.

This uniformity of physical conditions throughout the soil profile is characteristic of many important catchment areas in East Africa and persists to great depths, up to 60 ft. of developed latosol being shown by some borehole records. The reproducibility of this measured 'field capacity' permits the calculation of the drainage contribution to ground water[4].

At altitudes of between 8,000 and 9,000 ft. the heavy rain forest gives place to a dense cover of bamboo (*Arundinaria alpina*), and in this zone the development of a very large softwood industry is in progress. After some 30 years of measurements on sample plots and small plantations by the Kenya Forest Department, the Ministry of Forests has begun large-scale development, designed to provide employment for Kikuyu families displaced by the Mau Mau emergency. For ten years the comparative water use of bamboo and of softwood plantations has been studied by this Organization in co-operation with the Kenya Forest Department[9]; the evidence has been adequate to indicate that no hydrological ill-effects would be likely to follow replacement of bamboo by softwoods. The first major scheme was, however, sited in the catchment area of Nairobi City's future water supplies, and plantation therefore began with the development of experimental catchments.

Table 1. Field Capacity under Tall Rain Forest
(A latosol weathered *in situ* from phonolite)

Depth (ft.)	Range (in.)	Soil cores at tension of 1/3 atm.		Sampling results		
		Moisture (per cent dry weight)	Inches of water	April 1958	July 1958	June 1959
Surface	0–6	69·9	2·45	3·08	2·59	2·89
At 1 ft.	6–18	62·7	5·02	4·66	4·92	4·82
At 2 ft.	18–30	58·0	5·34	5·18	5·29	5·24
At 3 ft.	30–42	53·9	5·23	5·41	5·45	5·50
At 4 ft.	42–54	56·7	5·39	5·26	5·29	5·41
At 5 ft.	54–66	57·0	5·70	5·58	5·74	5·61
At 6 ft.	66–78	57·1	5·60	5·48	5·41	5·25
At 7 ft.	78–90	55·8	5·58	5·49	5·40	5·45
At 8 ft.	90–102	55·4	5·60	5·55	5·60	5·53
At 9 ft.	102–114	55·6	5·62	5·82	6·07	5·68
At 10 ft.	114–126	57·6	6·05	5·93	5·12	5·95
Total for 10½ ft. depth			57·58	57·44	57·88	57·33

Two evaporation pans, one raised, and the other sunken but air-insulated[10], gave totals of 48·57 and 49·58 in. respectively, while the Penman formula, using sunshine hours, gave 54·83 in. Sunshine hours give a somewhat inadequate account of the radiation under these typical mist-forest conditions, and substitution in the Penman formula of direct measurements of radiation by the Gunn–Bellani distillation instrument[10] gave an evaporation estimate of 48·82 in., in remarkably good agreement with the pan measurements.

The comparison of the forested and cleared valleys is summarized briefly in Table 2.

Table 2. Comparative Water Yields of Bamboo Forest and First Year of Cultivated Clearing

Annual totals	Valley *C* (161 acres, undisturbed bamboo forest)	Valley *A* (87 acres, cleared and clean cultivated for vegetables)
Rainfall	100·45 in. (from 9 gauges)	93·34 in. (from 10 gauges)
Stream-flow	56·78 in.	65·10 in.
Water yield	57 per cent	69 per cent
Water loss	43·67 in.	29·24 in.
Measured evaporation	49·00 in.	49·00 in.
Ratio $\frac{\text{evapotranspiration}}{\text{open water evaporation}}$	0·9	0·6

Confirmation that evapotranspiration from this bamboo forest approaches and sometimes equals potential open water evaporation rates has been obtained in the preliminary local experiments, so that the ratios obtained in Table 2 are in accord with previous experience.

The saving in water yield was thus about 12 per cent of the rainfall in the first year after clearing. This saving was achieved under a clean-tillage form of land use, in which the potatoes, peas, beans, etc., covered only part of the soil surface for part of the time.

This is a rather small saving in comparison with the 27 per cent of a 62 in. rainfall reported by Hoover[11] as gained by clear-felling a mixed hardwood forest in the colder conditions of the Appalachian Mountains. The difference is probably due to the rapid establishment of crops or weed cover under tropical conditions. Soil moisture sampling where clear-felling had not been followed by clean tillage showed that the very rapid growth of tall herbs (*Leonotis* sp., *Sambucus abyssinica*, etc.) had depleted the first 6 ft. of soil by 6 in. of water during a severe dry season in the first year after felling[9].

This aspect is sometimes overlooked by engineers in search of increased water supplies. Suggestions that water supplies may be improved by felling trees on tropical catchments pre-suppose that an alterna-

tive form of vegetation affording equally effective protection from erosion can be economically maintained; from experience with the comparatively shallow-rooted grasses of temperate-zone catchment areas, a grass cover is often strongly advocated.

It is planned to change one of the bamboo forest catchments to sheep-pasture in order to make this comparison, but the climax indigenous grass species, which rapidly invades and defeats all others planted in this area, is *Pennisetum clandestinum* or Kikuyu grass. A local farming observation at 7,000 ft. altitude has been that when a valley which gave rise to a permanent stream was cleared of bush and planted with this grass, the stream dried up and has remained dry for 15 years of permanent pasture. Washing out of grass roots showed that they entered decomposed lava at a depth of 19 ft. Detailed soil moisture studies to a depth of 15 ft. for 5 years in the catchment of the dried-up stream have shown that in each of the two annual rain-seasons the rainfall can be stored in this root range to be transpired during the two dry seasons, so that no surplus is available for stream-flow. Kikuyu grass pasture does not, therefore, offer a hydrologically attractive alternative to trees.

In addition to food and gainful employment for several hundred Kikuyu families the rotational clear-felling of pine or cypress plantations, followed by clean cultivation of vegetables intercropped between the seedling trees of the next rotation, at present appears to offer the best prospect of increasing water supplies from the mountain catchments of the Aberdares, now under dense bamboo forest.

The concentration of rainfall into the tropical wet seasons is so acute that not even the combination of heavy forest and deep porous soils can succeed completely in the even regulation of stream-flow. The best catchments under study give ratios of 20 : 1 for maximum to minimum flow rates. When cleared of forests and eroded by overgrazing, some similar East African catchments have given ratios exceeding 3,000 to 1.

The work outlined in this paper is progressing as a result of financial support from five East African Ministries and through the personal interest and co-operation of individual technical officers in some fifteen separate departments. Together they are making possible the quantitative evaluation of water relationships on which land-use policies for our catchment areas can be soundly based.

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FRACTIONATION PHENOMENA IN NUCLEAR WEAPONS DEBRIS

By K. EDVARSON, KERSTIN LÖW and J. SISEFSKY
Research Institute of National Defence, 4th Division, Stockholm 80

As is well known, a chemical fractionation of nuclear weapon debris takes place during the particle formation which occurs within the first few minutes after the explosion. A discussion of the particle formation phenomena has been given by C. E. Adams *et al.*[1].

In the present article some studies of the distribution of different fission products in air-borne bomb debris are reported and an attempt to interpret the results has been made.

The debris was sampled over the middle of Sweden with a filter-device carried by a jet-plane. The filter-medium was glass-fibre-paper (an investigation of the filtering efficiency has been published elsewhere[2]). The sampling took place at an altitude of 8–12 km. and the air mass filtered was usually 100–250 kgm.

A quarter of each sample was measured by γ-spectrometry and a quarter was autoradiographed. The γ-spectrometer consisted of sodium iodide (Tl) crystal (1¼ in. diam. × 1 in.) and a 70-channel kicksorter. The autoradiographs have been used to give a general picture of the activity distribution on particles and also as an aid for the isolation of individual particles (cf. ref. 3). The general trend seems to be that in fresh debris (a few weeks old) a relatively great portion of the activity is concentrated on particles larger than 1μ, whereas in older debris the activity is more evenly distributed on smaller particles.

By means of the autoradiographs it was possible to locate the more radioactive particles within some tenths of a mm. and these particles could be isolated from most of the remaining activity by punching out a small area of the filter containing the particle. In this way a number of samples were divided into fractions, each containing particles in a given activity range. As a rule two particle fractions named K_1 and K_2 and one fraction consisting of the remainder of the filter (R) were taken (cf. Table 1). By γ-spectrometry the content in each fraction of the following nuclides was determined: (zirconium + niobium)-95, ruthenium-103, iodine-131, lanthanum-140, cerium-141.

The results of the measurements for a number of samples are given in Table 1. At the time these studies were started we had not developed a technique for size-determination of the particles. Later on, however, it was possible to make a rough correlation between activity, age and particle size (cf. ref. 4). In Table 1 the particle diameter limits of the fractions are given.

The analysis showed that the compositions of the two (three) fractions from the same filter were different, as a rule in such a way that the K-fractions were strongly enriched in (zirconium + niobium)-95 and impoverished in ruthenium-103 while the other nuclides took a middle position. Observations of this kind have also been made by May and Schneider[5] and Sittkus[6].

Table 1

Sample	Size of measured sample (kgm. air)	Lower limit of fractions: pc per particle	Lower limit of fractions: μ	Number of particles per kgm. air	(Zr+Nb)-95: pc/kgm. air	(Zr+Nb)-95: Per cent	Ru-103: pc/kgm. air	Ru-103: Per cent	I-131: pc/kgm. air	I-131: Per cent	La-140: pc/kgm. air	La-140: Per cent	Ce-141: pc/kgm. air	Ce-141: Per cent	Date of sampling	Period of autoradiography	Date of measurement
117 K	16·4	60	1·0	1·3	78	39	6·3	7	2·9	11	4·8	8	29	20	12.9.57	17–25.9	30.9
R					123	61	82	93	24	89	58	92	116	80			
119 K_1	12·3	50	1·2	7·0	136	41	9·3	9	(2·0	12)	7·2	11	40	21	20.9.57	1–4.10	7.10
K_2		3	0·2	24	84	25	15	15	2·9	19	12·4	19	40	21			
R					114	34	81	76	11	69	44·5	70	111	58			
120 K_1	23·9	50	1·2	1·4	55	48	1·3	6	(0	0)	2·9	20	16	30	27.9.57	1–4.10	10.10
K_2		3	0·2	14	25	21	3·8	17	1·3	21	0·8	6	7·3	14			
R					36	31	17	77	5·0	79	10	74	29·6	56			
121 K_1	16·6	50	1·2	4·2	96	52	1·7	4	(0·3	3)	3·8	19	24	30	27.9.57	1–4.10	10.10
K_2		3	0·2	19·6	37	20	5·7	13	1·3	11	1·3	7	12	15			
R					48	27	36	83	10	86)	15	74	44	55			
132 K	23·2	30	1·4	2·8	144	35	0	0	—	—	1·5	9	12	9	25.11.57	[illegible]12	17.12
R					263	65	110	100	—	—	15	91	118	91			
136 K	23·4	30	1·4	1·7	26	15	0	0	—	—	(0·9)	(9)	3·5	5	6.12.57	12[illegible]	17.12
R					149	85	58	100	—	—	9·7	91	65	95			
153 K	45·5	30	1·9	0·26	4·5	16	0	0	—	—	—	—	0·4	5	24.2.58	25–26.2	1.3
R					25	84	64	100	—	—	—	—	6·6	95			
154 K	20·8	30	1·9	1·1	18	3	0·7	0·5	—	—	—	—	1·4	1	24.2.58	25–26.2	1.3
R					567	97	147	99·5	—	—	—	—	149	99			
159 K	174	—	5	0·006	7·3	100	0·8	100	0·8	100	1·2	100	6·3	100	7.3.58	8–10.3	17.3
161 K	87·0	90	1·6	0·39	26	54	1·8	20	4·2	72	7·6	80	20	68	17.3.58	18–19.3	20.3
R					22	46	7·2	80	1·7	28	1·9	20	9·5	32			20.3
162 K	53·6	90	1·6	0·11	9·8	29	0·9	11	1·8	41	3·0	53	8·4	46	17.3.58	18–19.3	
R					24	71	6·9	89	2·5	59	2·7	47	9·9	54			
164 K_1	41·1	90	1·6	0·98	47	39	1·6	7	4·9	39	14	55	29	46	25.3.58	26–27.3	28.3
K_2		9	0·4	1·7	11	9	1·0	5	1·7	14	3·6	14	7·9	13			
R					62	52	20	88	5·9	47	7·7	31	5·5	41			
166 K_1	19·5	90	3·4	1·1	115	26	2·1	3	—	—	—	—	9·8	9	8.4.58	24–30.6	3.7
K_2		9	1·5	12	82	19	4·7	7	—	—	—	—	14	13			
R					243	55	65	90	—	—	—	—	82	78			
167 K_1	47·2	90	3·4	0·17	28	40	0·4	4	—	—	—	—	3·4	20	17.4.58	24–30.6	10.7
K_2		9	1·5	1·1	11	15	0·3	3	—	—	—	—	1·6	10			
R					30	45	10·4	93	—	—	—	—	12	70			
168 K_1	19·9	90	3·4	1·7	262	45	3·6	4	—	—	—	—	32	25	17.4.58	24–30.6	3.7
K_2		9	1·5	8·7	85	15	5·1	6	—	—	—	—	13	10			
R					239	40	74	90	—	—	—	—	87	65			

(Values in brackets are uncertain)

These findings might be due to two effects. One is that the different fractions originate from different explosions, the other that fractionation phenomena have occurred. In the first case the youngest fraction ought to have, for example, higher iodine-131/(zirconium + niobium)-95 and lanthanum-140/(zirconium + niobium)-95 ratios than the older. If this were the only explanation of the data, the *K*-fractions should in most cases be the oldest. As it is almost invariably found that particles of high activity mainly occur during the first months after an explosion this is a rather incredible explanation. It seems more probable that fractionation phenomena are the main reasons for the differences in composition. In a few samples (zirconium + niobium)-95 was impoverished in the *K*-fractions. In these cases it was found from observations of samples taken a few days before and after that this deviation from the normal must be due to an admixture so that the *R*-fraction contained both old and young activity, whereas the *K*-fraction contained almost exclusively the young activity.

In most cases it was possible to establish the origin of the debris from known dates of test-explosions and the lanthanum-140-(zirconium + niobium)-95 ratio in the total sample. In these cases the values found have been compared with the theoretically expected in the following way. A fractionation factor $f_{A\text{-}95}$ for a given nuclide A is defined in the following way:

$$f_{A\text{-}95} = \left(\frac{N_A}{N_{(Zr+Nb)95}}\right)_{exp.} \cdot \left(\frac{N_{(Zr+Nb)95}}{N_A}\right)_{theor.}$$

where N is the activity of the nuclide in question. The first bracket contains the experimental and the second the theoretical values, as obtained from known fission yield values if the age is known. The yield values for fast fission of uranium-238 have been used, as all the samples in question contained uranium-237, indicating that they originated from thermonuclear devices with uranium-238 tamper. The assumed yield values are given in Table 2.

Table 2. Assumed Fission Yields for Fast Fission of Uranium-238 (ref. 7)

Mass-chain	Yield (per cent)	Mass-chain	Yield (per cent)
95	5·5	140	5·9
103	6·4	141	5·6
131	3·3		

In Table 3 the fractionation factors for the different mass-chains are given. As is evident from Table 3 there exists a definite trend in the fractionation factors. In the *K*-fractions the fractionation factors increase in the order ruthenium-103, lanthanum-140, (iodine-131), cerium-141 and (zirconium + niobium)-95 and are quite small for the first nuclides in this sequence.

It is possible to explain this trend qualitatively from the chemical properties of the elements in the mass-chains at the time of particle formation.

As the debris probably emanated from thermonuclear devices it seems reasonable to assume a yield of the order of magnitude 1 Mt. In this case the particle formation probably occurs about 15–20 sec. after the explosion. In Table 4 the element composition of the mass-chains 17 sec. after instantaneous fast fission of uranium-238 are given. It has been calculated assuming equal chain-length, using the values of Z_A and fractional yield versus

Table 3. Fractionation Factors

Sample	Mass-chain 103	131	140	141	Assumed date of explosion
117 *K*	0·1	0·2	0·1	0·4	22.8.57
R	0·8	1·2	0·9	1·0	
119 K_1	0·1	(0·2)	0·1	0·3	22.8.57
K_2	0·2	(0·4)	0·4	0·5	
R	0·9	(1·0)	1·0	1·1	
120 K_1	0·0	(0·0)	0·2	0·4	22.8.57
K_2	0·2	(0·7)	0·1	0·4	
R	0·7	(1·9)	0·9	1·1	
121 K_1	0·0	(0·1)	0·1	0·3	22.8.57
K_2	0·2	(0·5)	0·1	0·4	
R	1·0	(2·9)	0·9	1·2	
132 *K*	0·0		0·2	0·2	24.9.57
R	0·9		1·0	0·8	
136 *K*	0·0		(0·6)	0·3	24.9.57
R	0·9		1·1	0·8	
153 *K*	0·0			0·3	24.9.57
R	1·1			1·0	
154 *K*	0·2			0·3	24.9.57
R	1·1			1·0	
159 *K*	0·1	0·2	0·1	0·6	25.2.58
161 *K*	0·1	0·3	0·2	0·6	25.2.58
162 *K*	0·1	0·3	0·3	0·7	25.2.58
164 K_1	0·0	0·4	0·4	0·6	25.2.58
K_2	0·1	0·6	0·4	0·7	
166 K_1	0·1			0·3	25.2.58
K_2	0·2			0·6	
R	1·1			1·1	
167 K_1	0·1			0·5	25.2.58
K_2	0·1			0·6	
R	1·3			1·4	
168 K_1	0·1			0·4	25.2.58
K_2	0·2			0·5	
R	1·1			1·2	

(Values in brackets are uncertain)

(Z–Z_P) given by Grummit and Milton[8], and the half-lives of the short-lived fission-products given by Bolles and Ballou[9]. The value of ν has been assumed to be 2.

Of the elements in question, barium, strontium, yttrium, zirconium form oxides stable at high temperatures with the vapour pressures decreasing in this order. Cæsium, molybdenum, tin, antimony and tellurium form volatile stable oxides or are volatile in elemental form. From these properties it can be expected that the material condensed at an early stage is enriched in mass-chain 95 and impoverished in 103, 131 and 140, whereas 141 is somewhere between. If it is assumed that the large particles in average consist of early condensed material the observed fractionation factors are thus qualitatively explained.

From Table 3 it is also found that the fractionation in the *R*-fractions seems to be small.

If most of the activity is bound to small particles ($< 1\mu$ diameter) at the condensation, the fractionation in the *R*-fraction may well be small although it is

Table 4. Calculated Composition of the Mass-chains 17 sec. after Fast Fission of Uranium-238

Mass-chain	
95	20 per cent Sr + 70 per cent Y + 10 per cent Zr
103	5 per cent Nb + 65 per cent Mo + 30 per cent Tc
131	2 per cent Sn + 95 per cent Sb + 3 per cent Te
140	40 per cent Xe + 50 per cent Cs + 10 per cent Ba
141	30 per cent Cs + 70 per cent Ba

appreciable in the *K*-fractions. It should be noted that the particle spectrum in a sample collected a long time after the explosion is quite different from the original due to the change in settling rate with particle size. Thus the fact that the *K*-fractions sometimes constitute quite a large part of the samples does not contradict the explanation given above.

[1] Adams, C. E., *USNRDL-TR-209*, 1958.
[2] Sisefsky, J., *Nature*, **182**, 1437 (1958).
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[4] Sisefsky, J., Report Res. Inst. Nat. Def. (in preparation).
[5] May, R., and Schneider, H., *Atomkernenergie*, **4**, 28 (1959).
[6] Sittkus, R., *Naturwiss.*, **46**, 399 (1959).
[7] Prawitz, J., Report Res. Inst. Nat. Def. (in preparation).
[8] Grummit, W. E., and Milton, G. M., *AECL-453* (1957).
[9] Bolles, R. C., and Ballou, N. E., *USNRDL-456* (1956).

A NEW SERVICE FOR NATURALISTS

By R. S. R. FITTER

Director, Intelligence Unit, Council for Nature

THE Intelligence Unit of the Council for Nature, which was set up in May 1959, with the aid of a grant of £5,000 a year for three years from the British Broadcasting Corporation, is now ready to deal with requests for information about field natural history in the United Kingdom. The Unit has a staff of four and maintains contact with active field naturalists and natural history societies in all parts of the United Kingdom, and is especially interested in their field work. Some two hundred of these societies are already members of the Council for Nature, and the Unit hopes, before long, also to extend its intelligence system to those societies which are not members.

The Unit will act as a clearing house rather than an information bureau and primary source of information. It will aim to pass inquirers on to the best sources of information and works of reference, rather than give direct answers to factual queries, though, of course, these will be given whenever possible. The sort of queries the Unit hopes to be asked are of the type: "Who are the leading experts on the otter or the peregrine falcon in the British Isles?" or "Who is an authority on the effects of toxic sprays on bird and insect life?", or "Who can say what is likely to be the effect on wild life in the vicinity of a nuclear power station on the coast of Suffolk?" Questions that can be looked up in a work of reference, such as "How long can an otter live?" or "What is the breeding season of the peregrine falcon?", will, it is hoped, not be directed at the Unit in too great numbers, as this will stultify the real aim of the service the Unit seeks to provide. The Unit will also not expect to be asked to identify specimens (though it will advise on where such help may be obtained), or to give advice relating to pets, domestic animals or cultivated plants.

The broader aims of the Intelligence Unit are to build up a picture of the field work being carried out by naturalists all over Britain, ascertain what gaps there are, and put naturalists working on similar problems in touch with each other. Among other services which the Unit provides for the Council is the editing of the Council's half-yearly bulletin, "News for Naturalists", the second issue of which is being published in December. This bulletin is not for sale, but is available free to member societies and their individual members.

The work of the films officer, Stanley Jeeves, covers the whole field of still and ciné photography by amateurs interested in natural history, but to start with is mainly concentrating on the ciné aspects. Recently, a most successful experimental beginners' course of instruction for amateur cinematographers was held at the offices of the Council for Nature, in South Kensington. Twenty-three 'students' attended and heard talks on technique and equipment by Stanley Jeeves and on the work of the British Broadcasting Corporation Natural History Unit at Bristol, by Tony Soper. Afterwards, they watched films taken by three of their number, on vole damage, by Oliver Hook, on waxwings, by J. W. Carr, and on terns, by F. G. Hollands.

The experimental course was so successful that the Unit plans to organize another one on similar lines in the north of England, perhaps at Manchester, early in the New Year, and possibly also in Scotland. There will probably also be a two-day course, with a slightly more advanced syllabus, in London in the New Year, and this may also be repeated in the north. A still more ambitious scheme is planned for next May, when the Unit will hold a week's course for amateur cinematographers at Brantwood, Ruskin's Lake District home, which is now run by the Extra-Mural Department of the University of Manchester as an adult education centre. At this course it will be possible to give instruction actually in the field, and to make and edit one or more short films.

Another activity of the Films Section of the Unit is the organization of two competitions for amateur cinematographers interested in wild life. The first, for 35 mm. (and 16 mm. at 24 frames) films, is being organized jointly by the Council for Nature and the British Broadcasting Corporation, which has generously offered two prizes, £500 for a full-length 20–30-min. film, and £50 for a 3–8-min. sequence. This competition is not open to those who have already had more than 10 min. of consecutive film shown on television. The aim of the competition is to stimulate new talent in the field of natural history cinematography, of which, of course, the British Broadcasting Corporation, and especially its Natural History Unit at Bristol, are big consumers.

The second competition is for 8 mm. (and 16 mm. at 16 frames) film, and is primarily for the many amateurs who cannot yet aspire to a 16 mm. camera. The prizes are being presented by manufacturers of equipment, the first prize being a Paillard Bolex reflex camera worth about £400. Further information about both competitions and the instructional courses can be obtained from the Films Officer, Council for Nature, 41 Queen's Gate, London, S.W.7.

A further activity on the films side is the compiling of a comprehensive list of natural history films, and more especially those available for public showing. This is being carried out in collaboration with Mr. Michael Gwynne and the Botany Department of the University of Oxford.

NEWS and VIEWS

Ministry of Aviation Appointments : Dr. C. H. Johnson, C.B.E.

BRIEF notes referring to promotions in the Ministry of Aviation were printed in *Nature* of November 7, p. 1448 ; further information is now available.

Dr. C. H. Johnson, who has been promoted to chief scientific officer and appointed director of the Explosives Research and Development Establishment, Waltham Abbey, Essex, in succession to Dr. W. H. Wheeler, on the latter's acceptance of an industrial post, graduated from University College, London, with first-class honours in chemistry in 1925 and a Ph.D. and the Ramsay Medal in 1927 for work under Prof. W. E. Garner concerned with explosive reactions in gases. The next two years were spent on research (the chemical and biological effects of ultrasonic energy) and teaching at the University of California. He rejoined Prof. Garner at the University of Bristol in 1930, initially as assistant lecturer in physical chemistry. In 1937 he was appointed senior lecturer in inorganic chemistry in the University of Birmingham, where he continued his researches, begun at Bristol, on co-ordination compounds, particularly those showing optical activity. He was awarded his D.Sc. (London) in 1940. Commencing some months prior to the outbreak of the Second World War, in association with members of the Department of Chemistry of the University of Birmingham, under the late Sir Norman Haworth, Dr. Johnson took part in a survey of volatile compounds of uranium and in attempts to isolate uranium metal in bulk. In 1942 he joined Shell Refining and Marketing Co., Ltd., and became manager of the Lubricating Oil Laboratory, then in process of formation at Thornton, Cheshire, and later, also, of the Diesel Fuel Laboratory, built in 1946. These laboratories were afterwards incorporated (with two others) in Shell Co.'s Thornton Research Centre. Dr. Johnson entered Government service in 1948 as superintendent of propellant research at the Explosives Research and Development Establishment and became chief superintendent in 1950. Since 1954 he has been director of materials and explosives research and development at Ministry of Supply headquarters in London.

Mr. W. H. Hill

MR. W. H. HILL has been promoted to deputy chief scientific officer and appointed to the post of deputy director of air armament in the Ministry of Aviation. Since 1954 he has been superintendent of the Weapons Assessment Branch of the Armament Research and Development Establishment, where he has been responsible for important advances, particularly in the application of modern techniques to a field of increasing complexity and importance in armament development. Mr. Hill obtained his degree at the University of Cambridge. Following some four years on the academic staff of the University College of the South West, lecturing in applied mathematics, he spent the period 1941–46 in war service, retiring with the rank of major in the Royal Electrical and Mechanical Engineers, and in 1946 joined the scientific staff of the War Office, serving first with the Army Operational Research Group and later on the staff of the Scientific Adviser to the Army Council. He was transferred to the Ministry of Supply in 1952 and spent some eighteen months in the Guided Weapons Department of the Royal Aircraft Establishment before his promotion in 1954.

Mr. S. A. Hunwicks, O.B.E.

MR. S. A. HUNWICKS has been promoted to deputy chief scientific officer and appointed director of Atomic Weapons (Development), Ministry of Aviation. He started his career in 1930 in the Department of Engineering at the National Physical Laboratory, where he worked mainly on the strength of materials at high temperatures and lubrication problems. In 1934 he graduated in engineering at London. In early 1939 he joined the Armament Department of the Royal Aircraft Establishment and gained a wide experience on research, development and design of airborne weapons. From 1943 he was responsible for full-scale trials on airborne rockets, including development of techniques for measuring air and underwater ballistics. During this period he initiated and carried out the establishment of several Royal Aircraft Establishment ranges, including Lake Alwen in North Wales. In 1946 Mr. Hunwicks was one of the Ministry of Supply scientific team seconded to the Department of Supply, Australia, for the setting up of the Long Range Weapons Establishment at Salisbury, South Australia, and the Woomera Range. His special responsibilities were air facilities, the bomb ballistic range which was the first range operating at Woomera, and staff recruitment. On returning to Great Britain, he rejoined the Armament Department, Royal Aircraft Establishment, in 1949, becoming section head responsible for the design and development of special weapons. In 1954 he attended the Administrative Staff College, and shortly afterwards was promoted to superintendent in the Armament Department responsible for the co-ordination of all Royal Aircraft Establishment work on free-falling weapons.

Mr. A. N. Christmas

MR. A. N. CHRISTMAS has been promoted to deputy chief scientific officer and appointed director of Guided Weapons (Techniques) at the Ministry of Aviation Headquarters. Mr. Christmas graduated with first-class honours at the University of London in engineering in 1933, and after a period of research in industry joined the government service in 1937 as an assistant engineer in the Radio Branch of the General Post Office Engineering Department. In 1946 he was attached to the Ministry of Supply for work at the Royal Aircraft Establishment on control systems for guided weapons. In 1947 he transferred to the Ministry of Supply and continued his work on guided weapons at the Royal Aircraft Establishment until 1951 when he was posted to the United States and for three years was a member of the Ministry of Supply staff at the British Joint Services Mission in Washington. During this time he was responsible for liaison work covering the whole field of guided weapon research and development in the United States. In 1954 he was promoted to senior principal scientific officer and returned to

Great Britain to take up the post of superintendent of the V.T. Fuze branch of the Armament Research and Development Establishment. In his new post Mr. Christmas will be responsible for directing research and development on guided weapons techniques, including guidance and control, propulsion and advanced engineering techniques specially applicable to guided weapons.

British Contribution to High-Altitude Research

It was decided at a meeting of the International Committee on Space Research in the spring that great scientific value was to be gained from the simultaneous, or nearly simultaneous, firing of many rockets in different parts of the world carrying identical or related experiments. It was hoped that all countries participating in high-altitude research with rockets would launch one or more, the elucidation of atmospheric structure being a particular aim of the experiments. The British contribution has been developed jointly by the British National Committee on Space Research set up by the Royal Society and the Royal Aircraft Establishment of the Ministry of Aviation, and consists of experiments carried by the upper-atmosphere research rocket *Skylark*. This rocket is powered by the Raven solid-propellant motor designed by the Rocket Propulsion Establishment, Westcott. The rocket is launched with the co-operation of the Weapons Research Establishment at Woomera in Australia. The programme was to launch three rockets, and these were all fired in the space of 36 hr. on November 30 and December 1.

The first *Skylark* carried the sodium vapour experiment devised by the Queen's University of Belfast. Sodium vapour, ejected from the rocket at heights greater than about 40 miles, gives a resonance glow when observed under the correct twilight conditions. Optical observations of this glow, made with an interferometer and with ballistic cameras, can give data leading to both atmospheric temperature and wind structure. The second *Skylark* was to measure the atmospheric temperature and horizontal and vertical wind speeds up to heights of 90 miles using a sound-ranging method. This is based on the optical and acoustical observations of explosive grenades, ejected from the rocket at regular intervals. This experiment is the responsibility of a group at the Physics Department, University College, London. In addition, metal foil was ejected from the rocket and observed by radar, enabling an independent estimate of wind speed and direction to be made by a group at the Department of Meteorology, Imperial College of Science and Technology, London. The third *Skylark* carried three experiments: measurement of atmospheric temperature and horizontal and vertical wind-speeds using the grenade sound-ranging method (University College, London); measurement of wind characteristics by using radar observations of metal foil ejected from the rocket (Imperial College, London); and measurement of electron densities in the ionosphere (Department of Electron Physics, University of Birmingham).

New Australian Botanical Laboratory

The new Australian Commonwealth Scientific and Industrial Research Organization's Cunningham Laboratory, which was recently opened by the Prime Minister of Australia, Mr. Menzies, occupies a three-acre site in the grounds of the University of Queensland at St. Lucia, a suburb of Brisbane. It was completed this year at a cost of £180,000. The Government of Queensland provided the site, contributed £15,000 towards the cost of the building, and built the access roads at a further cost of £10,000. The work of the Cunningham Laboratory is particularly concerned with pasture improvement in four regions known as the Wallum, the Spear Grass Zone, the Brigalow Scrubs, and the Darling Downs. These regions constitute an area of about 70 million acres, which is considerably larger than the State of Victoria. Officers of the Division of Tropical Pastures (the main group housed in the Laboratory) hope to introduce a number of new grasses and legumes into Queensland pastures. Plant collection officers who understand Queensland conditions have already collected promising species from South America, Africa, Hawaii, the United States, India, Ceylon, Mexico, the West Indies and Central America.

Preservation of Cornish Scenery

The Minister of Housing and Local Government has confirmed an order made by the National Parks Commission under the National Parks and Access to the Countryside Act 1949, which designates about 360 square miles of Cornwall as an "area of outstanding natural beauty", and not as a national park. The designated areas include some of the finest and best-known coastal scenery in Britain, and Bodmin Moor. A large part of the Land's End peninsula, a coastal strip from St. Michael's Mount to Porthleven, and the whole of the Lizard peninsula, including the beautiful Helford Estuary, to the outskirts of Falmouth are covered by the order, while other parts of south Cornwall included are the territory between St. Mawes and St. Austell, the Fowey Estuary to West Looe, and Rame Head to Mount Edgcumbe, overlooking Plymouth Sound. In north Cornwall, the whole of the coast between the Devon–Cornwall county boundary, at Marsland Mouth, and Bedruthan Steps, north of Newquay, is included, apart from an area around Bude and part of the Camel Estuary between Polzeath and Padstow. The order also covers the coast from Perranport to south of St. Agnes Head, and between Portreath and Godrevy Towans. The responsibility for preserving and enhancing the natural beauty of the landscape rests with the local planning authority, Cornwall County Council. Government grants can be made at the rate of 75 per cent towards the cost of treating derelict land, tree-planting and preservation, and removing disfigurements. Grants are also available towards expenditure incurred in making agreements or orders for public access to open country and in appointing wardens. Designation does not provide any right of access to land not already open to the public; nor does it affect the existing use of land, for example, the use of War Department land for military purposes.

Darwin Centenary

For the first time, a number of the *Notes and Records of the Royal Society of London* has been devoted to a single topic (**14**, No. 1; June 1959). Its main purpose is to celebrate the centenary of the publication of "Origin of Species", and this has been done most adequately. It contains a fascinating collection of unpublished letters of Charles Darwin as well as an article on A. R. Wallace which, *inter alia*, directs attention to his essay of 1855; this hitherto appears to have escaped notice. There are also bio-

graphical sketches of the four men who probably had most influence on Darwin—Erasmus Darwin, Lyell, Hooker and Malthus. The essay on Malthus by Prof. H. J. Habakkuk is of special interest and shows how, with his writings on population, Malthus provided the clue to the origin of the species both for Darwin and for A. R. Wallace. This special copy of *Notes and Records* was designed to pay tribute to Darwin, and in itself is a tribute both to him and the Society which sponsored it.

Education as a Career

THE Ministry of Education has published a pamphlet intended to give university students a picture of the opportunities which exist for men and women to follow a career in education ("A Career in Education for University Graduates". Revised edition. Pp. 15. London: Ministry of Education, 1959). It describes the training and types of work open to university graduates who become schoolmasters and schoolmistresses, with particular reference to work in grant-aided schools. It also refers to the financial aid available towards the cost of training. The appendixes which follow give up-to-date facts about teachers' salary scales in schools and about teachers' pensions. They also include some information about opportunities for teaching in establishments of further education and training colleges, and for work in local educational administration and H.M. Inspectorate. There are also opportunities for educational work in a variety of other spheres, both in Great Britain and abroad, and some of these are described.

Handicapped Children

THE thirteenth in a series of special subject booklists prepared for the Library Association deals with handicapped children in Britain ("Handicapped Children in Britain—Their Problems and Education". Books and Articles published in Great Britain from the 1944 Education Act to 1958. Compiled by Mrs. W. A. Axford. Pp. 53. London: Library Association, 1959. 4*s*.). The compiler, Mrs. W. A. Axford, of the University of Birmingham Institute of Education, deserves the warmest praise for a painstaking task well done; the list includes details of books and articles published in Great Britain from the 1944 Education Act to 1958. The bibliography covers all types of physical and mental handicap, but not psychological or social handicaps. Articles of a purely medical nature are excluded unless they are of general interest. For easy reference the items are arranged in alphabetical sequence of subject headings.

Film Strips for Schools

DESPITE the exciting potentialities of moving films and television as means of evoking interests in schoolchildren, the teaching profession as a whole regards the still picture as an even greater aid to teaching. The moving picture awakens interest and captures attention; teachers use still pictures to ensure that factual knowledge is retained. For this reason, they will once again be grateful to the enterprising firm of Educational Productions, Ltd., for adding four more attractive and inexpensive coloured film-strips to its wide range. One, showing a variety of common garden insects, has been prepared by the well-known photographer, George Hyde, and would be of interest to horticultural clubs as well as in school biology classes. "Resident British Birds" has been prepared in collaboration with the Royal Society for the Protection of Birds; the photographs are by Eric Hosking and the script by Philip Brown. "Grasses" would be of particular use in sixth form and university botany classes, while "Seed Germination" should find a warm welcome in secondary modern, secondary grammar schools and others where biology is taught to the General Certificate of Education, 'Ordinary' level. (Educational Productions, Ltd. Filmstrip No. 5260: Insects in the Garden. 28 frames. 16*s*. 6*d*. Filmstrip CX 6290: Seed Germination. 23 frames. 27*s*. 6*d*. Filmstrip CX 6332: Grasses. 27 frames. 27*s*. 6*d*. Filmstrip CX 6208: Resident British Birds. 33 frames. 27*s*. 6*d*. East Ardsley, Wakefield: Educational Productions, Ltd., 1959.)

Evolution of the Human Brain

THE James Arthur Lecture on the Evolution of the Human Brain, given by Prof. D. P. C. Lloyd, entitled "The Discrete and the Diffuse in Nervous Action", has now been issued (pp. ii+28. New York: Amer. Mus. Nat. Hist., 1959). His central theme is Cajal's concept of "les réflexes unilatéraux circonscrits" and "les réflexes unilatéraux diffus". Much of Prof. Lloyd's work has been concerned with the functional implications of the anatomical distinction made by Cajal; and in this lecture he elaborates the idea that the circumscribed monosynaptic reflex is an accurate, rapid and discrete functional arrangement of advanced evolutionary status. On the other hand, the diffuse reflexes involving interneurones constitute an organized, although more plastic, system for synergic mass actions. The latter are to be distinguished from the primitive mass action systems of many invertebrates by the 'local sign' they exhibit in performance. There is little in this theme that is controversial, and much that can now be considered as consolidated in physiological thought: but Prof. Lloyd, as the author of a substantial part of the experimental evidence, develops the theme with great clarity and point.

Fodder Beet, Mangels and Swedes

REVISED leaflets describing varieties of fodder beet and mangel and of swedes have recently been issued by the National Institute of Agricultural Botany at Cambridge. In each of these crops the Institute has tested very large numbers of varieties, and these leaflets give details of the important root characters, the size of top and percentage bolters of the varieties which have proved most successful in the trials. These leaflets give the farmer the information he needs to make an intelligent choice from the bewildering range available. Copies can be obtained by sending a stamped addressed envelope, saying which leaflet is required, to the Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

Announcements

THE honorary officers and members of Council of the Association of Consulting Scientists for 1959–60 are: *Chairman:* Dr. J. G. Davis; *Hon. Treasurer:* Dr. G. W. Ferguson; *Hon. Secretary:* Mr. W. H. Stevens, Park House, Hawthorne Road, Bromley, Kent; *Members:* Dr. M. Barent, Dr. H. H. Chambers, Dr. J. Grant, Dr. J. H. Oliver, Mr. O. W. Roskill and Mr. F. G. Sarel Whitfield.

ERRATUM. In the communication entitled "A New Crystalline Salt of Oxytocin" in *Nature* of September 26, p. 981, par. 3, line 4, for "33 mμ" read "353 mμ".

PROGRESS IN COKE RESEARCH IN GREAT BRITAIN

An established annual event is the joint meeting of the Coke Oven Managers' Association, the Institution of Gas Engineers and the British Coke Research Association. These three institutions cover the technical interest of the carbonizing industries in all its facets. This annual gathering has become noteworthy for the fact that some matter of absorbing interest is discussed at the meetings.

It will be recalled that in the autumn of 1958 the Duke of Edinburgh opened the new Coke Research Centre of the British Coke Research Association at Chesterfield. A special feature of this research station is that it contains, besides chemical and physical laboratories, a large workshop laboratory for pilot-scale plant, an excellent information centre, and a full-scale plant for making coke and its by-products. This last feature was a bold venture, which had been in the minds of the practical men of the industry for upwards of a decade.

At this year's tripartite meeting, held recently, the director of the Research Association, Mr. G. W. Lee, gave an encouraging account of the work that had been carried out during its first year at the Coke Research Centre. Naturally, everyone was interested to hear how the full-scale plant had operated in practice, for the coke-oven manager knows full well the teething troubles that may be expected to be encountered in such an undertaking. Mr. Lee was able to unfold a story of quite substantial success.

The coke oven is to be used for producing sufficient coke to enable performance trials to be made of the resultant cokes in production blast furnaces. One cannot use less than a hundred tons of fuel for trial on an industrial unit of such magnitude. There is also a by-product plant to deal with the collection of tar and other products distilled from the carbonizing coal in the oven. To overcome all the teething troubles successfully in the coldest period of the year, when there was 17° F. of frost—and incidentally seventeen coke braziers required—was no mean achievement. To train also the composite team of operators, having both technical ability and practical experience of plant operation, to run the plant had been a problem in human relations. It has to be remembered that the plant was quite unique, and the carbonizing of each charge of coal a huge scientific experiment calling for accurate instrumentation, measurement of numerous values and precise analysis. In the upshot, the standard of repeatability of yields achieved was good, and in the final runs reported 'very good', in Mr. Lee's modest claims; we should say, in such demanding conditions, excellent.

Perhaps the most satisfactory outcome of these trials was to prove that the results of full-scale trials confirmed the usefulness of trials in smaller experimental ovens, a range of which the Association has for long been using. Such a situation makes for accelerated progress in the matter of producing still better qualities of coke from coals of diminishing suitability for the purpose, as the reserves of coking coal of good quality become depleted.

The Coke Research Association has established, as have other research associations in Britain, a world-wide reputation for the quality of its research. In the new Research Station the equipment and the staff are such that the good work can be continued at an accelerated pace. 40 per cent of its research effort is devoted to improvement in the quality and yield of coke, and 11 per cent to the thermal behaviour of coal and the fissuring of coke. The remainder is concerned with a wide range of fundamental and applied studies that the future welfare of the industry demands.

The layman is rightly concerned about the pollution of the air and of the rivers which industrialization carries in its train. These subjects have not been overlooked. The effluent problem in the coking industry has many features in common with that of the gas industry, and accordingly these industries have joined forces in tackling the water pollution problems that arise from their activities. The Coke Research Association is supporting both financially and technically the work of the Joint Research Committee and the University of Leeds through its Ammonia Effluents Sub-committee.

As regards the field of atmospheric pollution, investigations of the Coke Research Centre have included preliminary studies of the chemical and physical nature of the smoke emitted from a coke oven. Naturally, problems of suppression are also being studied.

All these matters that concern the future prosperity of the coal industry contain reassuring features of particular interest to those enlightened sections of the British public which already recognize that the future of coal must depend upon the technological effort put into its utilization.

SOIL SALINITY COURSE IN TUNISIA

Following an invitation of the Government of the Republic of Tunisia and with its sponsorship, Unesco's Middle East Science Co-operation Office organized a Regional Training Course on Diagnosis, Improvement and Management of Salt-affected Soils as a part of the Arid Zone Project. The course was held in Tunis during September 7–October 3, 1959. It consisted of one week of lectures, followed by two weeks of laboratory work and a field trip to the arid regions and saline soils in Tunisia.

The chemical aspects were treated by Dr. A. D. Ayers, formerly with the U.S. Salinity Laboratory, Riverside, California, now with the Agricultural Research Service U.S. Department of Agriculture, Rome; the geological and pedological aspects by Prof. G. Aubert, Institute of Tropical Soil Investiga-

tions, Office for Technical and Scientific Research for France Oversea, Bondy, France ; and the physical aspects by Prof. W. R. van Wijk, Agricultural University of Wageningen, Netherlands. Dr. Ayers served as general technical director.

Reclamation of saline soils and use of saline water for irrigation are problems of primary importance in Tunisia. This was stressed by the President of the Republic of Tunisia, Habib Bourguiba, who opened the conference and welcomed the group. Prof. Kovda, director of the Unesco Department of Natural Sciences and one of the foremost Russian soil scientists, thanked the president on behalf of Unesco. Prof. Kovda stayed at Tunis during the first week of the course. He and several French scientists, consultants to the Tunisian Government, gave lectures on special subjects as capillary rise of saline ground water, genesis of saline soils, Tunisian soils, plant associations in Tunisia, crop research in Tunisia, distribution and quality of surface and underground waters in Tunisia. The Secretary of State for Education, Mahmoud Messadi, the Secretary of State for Agriculture, Abdessalam Kenani, and many other Tunisian authorities attended at one or more lectures.

The lectures and laboratory work were held in the Ecole Supérieure d'Agriculture (director Prof. Haffani), where also the participants were housed. There were thirty-two participants from ten Middle East countries. Of these, fifteen were from Tunisia, the others from Iran, Iraq, Jordan, Lebanon, Lybia, Morocco, Sudan, Turkey and the United Arab Republic. Most of the participants were graduate staff members of universities or research institutes and several held responsible positions in their countries. The enthusiasm and interest of the participants contributed much to the success of the course.

The field trip was offered by the Tunisian Ministry of Education. Leaders were Prof. G. Aubert and Mr. Roederer, head of the Pedological Service of the Ministry of Education. First the Medjerda valley was visited where an ambitious and magnificent project of reclamation, land amelioration and irrigation is in progress. Thereafter the arid and desert areas in the south were visited where a variety of soils of different degrees of salinity were studied. The capriciousness of the weather and the statistical meaning of the concept of climate were convincingly demonstrated on that occasion. A heavy thunderstorm caused a delay of several hours before the 'Landrovers' could cross the flooded parts of the route Kairouan–Gafsa (annual precipitation between 4 in. and 8 in.) and the main road Gafsa–Tozeur was badly damaged. From Tozeur the field trip went to Kebili and Gabes, crossing the famous salt marsh of Chott el Djerid. The plans were to visit the fast saline area around Gabes. Again, however, a heavy thunderstorm interfered. The expedition was practically isolated for two days in Gabes as the environments were flooded, and then had to return to Tunis.

This note on the Salinity Course would be incomplete if no mention were made of the hospitality which the participants and in particular the Unesco instructors received from officials and private persons, Tunisian as well as French. On such visits the impressive achievements but also the still remaining problems of the young Republic in the fields of education, public health, organization and employment of labour were frankly discussed.

W. R. VAN WIJK

THE NATIONAL CHEMICAL LABORATORY

THE Report of the National Chemical Laboratory for 1958 follows the same general lines as previous reports (Department of Scientific and Industrial Research. Report of the National Chemical Laboratory, 1958. Pp. iv+97. London : H.M. Stationery Office, 1959. 5*s*. 6*d*. net). After a preliminary statement that the name of the Laboratory has been changed to indicate more precisely its true functions and that a steering committee is now responsible for the research programme, the Report sets out the various lines of work on which the Laboratory has been engaged. Broadly speaking, these fall into six main groups : the extraction of metals, the preparation of pure elements and compounds and the determination of their properties, the corrosion of metals, the development of new materials, analytical research and services, and microbiology. Some at least of these divisions have been represented by work in the Laboratory over a period of years, that on the corrosion of metals being a special case in point. Each year, however, new problems have come forward and as a result it appears that the staff of the Laboratory is now much larger than it was formerly.

In addition to its own work the Laboratory has for some years maintained an advisory service. Each year numerous inquiries are received for advice and assistance on all topics related to its own work, particularly such as concern the corrosion of metals and the purification of organic compounds. In addition, the Laboratory is often approached for advice on topics quite outside the scope of its researches. One example mentioned in the field of corrosion is that of the pitting of domestic copper piping in a housing scheme, and others show that this advisory service must be a valuable feature of the general activity of the Laboratory and that the problems coming in through it may sometimes prove very suggestive and important in relation to its own work.

The parts of the Report dealing with corrosion show that some fundamental work on the mechanism of corrosion is proceeding alongside investigations on various aspects of more directly practical interest, such as those on inhibitors. Work on the extraction of metals included studies of the extraction and recovery of uranium from a variety of cres, which is of interest to the United Kingdom Atomic Energy Authority, and on the separation of the rare earths. Of special interest is the section of the Report dealing with the preparation and properties of pure elements and compounds. In the case of metals it has long been known that the presence of even minute traces of impurities, sometimes so small as to prove extremely difficult to detect by ordinary analytical procedures, can lead to profound changes in properties such as hardness and chemical activity. The increasing importance of pure metals in modern metallurgical technology makes this part of the work of the

Laboratory of great interest. The zone-refining technique has necessarily played an important part.

The section of the Report dealing with the development of new materials is largely concerned with ion-exchange resins and the permeability of membranes. This part is written up in rather greater detail than the rest of the Report and hence makes interesting reading. The underlying ideas are more carefully presented, and there are good graphs of the results. As a general criticism it might be said that a good deal of the rest of the Report is presented so briefly that it cannot arouse much interest except among specialists, but the part on new materials does seem to have achieved something in this direction. It would be unfair to contrast with this the eleven-page catalogue of strains of bacteria at the end, but the different parts of the Report vary quite considerably in appeal to the non-specialist scientific reader, and perhaps in future greater attention could be given to this aspect. It has obviously been a difficult problem for the director and his staff to compress their material into pre-ordained limits, but a tendency to produce information as from one specialist to another has cramped the style in some cases.

The general work in the Laboratory now includes emission and infra-red spectroscopy, micro-analysis and polarography. The first two might seem to encroach to some extent on the field of the National Physical Laboratory, but the researches are evidently directed towards chemical problems. Some work on various compounds of boron is of interest although it seems to have been limited to organic compounds. The immediate aim, it is said, has been to provide background knowledge of the chemistry of the boron–nitrogen system and to prepare a range of intermediates from which thermally stable and other useful materials may be made. The general impression conveyed by the Report is that inorganic chemistry, which has now become of extreme importance, has perhaps received less attention than it should do, and the metals have, perhaps understandingly, monopolized a large share of the interest in the field.

The Report as a whole is a record of work of great value, but with the extension of staff and work the question must arise whether it is now possible to cover the results in an interesting and understandable way in less than a hundred pages. It is true that much of the work will ultimately be published in a more extended form, but it will then tend to be lost in the enormous field of specialist literature. It might be worth considering whether the Report could be enlarged to double its present size (and, of course, at greater cost to the purchaser) and an attempt made at the same time to deal with topics of wider interest in a way which would attract the general scientific reader. J. R. Partington

MUTATION OF BACTERIA AT HIGH LEVELS OF SURVIVAL BY ETHYL METHANE SULPHONATE

By ANTHONY LOVELESS
Chester Beatty Research Institute, London, S.W.3

AND

SHEILA HOWARTH
Guinness-Lister Research Unit, Lister Institute of Preventive Medicine, London, S.W.1

ETHYLATION was first described as a mutation-inducing process ("alkylation of the gene molecule") by Rapoport[1], who used diethyl sulphate as the reagent and *Drosophila melanogaster* as the test material. Subsequent work has revealed that ethylating agents appear to have unique properties as mutagens in a number of systems. Thus, treatment of phage *T2 in vitro* by either diethyl sulphate or ethyl methane sulphonate results in a considerably increased yield of both plaque-type and host-range mutants in the first cycle of infection by the treated phage of untreated cells of *Escherichia coli* strain *B* (ref. 2) and strain *B/r* (Loveless, unpublished). No other alkylating agents have so far been reported as sharing this property. Heslot *et al.*[3] have reported that the yield of mutants afforded by barley seeds treated with ethyl methane sulphonate much exceeds that of seeds treated with a wide variety of other alkylating agents; diethyl sulphate, also, was found to have unusual properties[4]. Kølmark[5] found that diethyl sulphate provoked an appreciable number of reversions at an inositol locus of *Neurospora* which had proved relatively intractable to other reagents. There is no evidence from the results of the Fahmys[6] of any dramatic mutagenic effect of ethyl methane sulphonate in *Drosophila* in comparison with its homologues, but it is probable that this compound was not tested at the high doses which its low toxicity, as measured in other organisms, might be expected to permit. D. M. Green (personal communication) has reported confirmation of the results with *T2* phage and an extension of the finding to *T4*.

There was thus reason for supposing that the unusual genetic effects of ethylation were widespread in the organic world, and we were accordingly prompted to investigate the mutagenic effect of ethyl methane sulphonate upon bacteria. We wish now to report the production, consequent upon treatment with this compound, of high yields of revertants of a cystine-requiring mutant of *Salmonella typhimurium* strain *LT2* and of mutations to phage *T6*-resistance in *Escherichia coli* strain *B* and *B/r*. In addition, preliminary experiments yielded five auxotrophic mutants of *S. typhimurium* strain *LT2* out of 1,090 colonies tested, each having a different nutritional requirement.

(1) *S. typhimurium* strain *LT2*, *cysA*-21[7] (requiring cystine) was grown in synthetic (*M*-9) medium plus cystine at 40 μgm./ml. from a 1 : 100 inoculum from an overnight culture in the same medium. At approximately 2×10^8 cells/ml. the culture was spun, washed in *M*-9 medium lacking cystine and resuspended at *c.* 10^{10}/ml. in a small volume (*c.* 3 ml.) of 0·4 *M* ethyl methane sulphonate for 15 min. treatment at 37° C. (Survival tests carried out independently showed that this treatment left about 70 per cent viable cells; in the mutation experiments the actual recovery was only 10–20 per cent owing,

at least in part, to losses in centrifugation. Since the treatment was given by re-suspending a centrifugal pellet with residual buffer, the final concentration of ethyl methane sulphonate was probably nearer 0·35 *M*. Care must be exercised in the use of ethyl methane sulphonate and some other alkylating agents[8] at concentrations nearing saturation since toxic effects other than those due to alkylation may become pronounced. (Ethyl methane sulphonate is saturated at about 0·5 *M*.) At the end of the treatment the suspensions were diluted tenfold into phosphate buffer to minimize further action, re-spun and re-washed to remove ethyl methane sulphonate, and plated on minimal medium enriched with 0·01 per cent dehydrated 'Difco' broth (*c.* $1{\cdot}5 \times 10^8$ or $1{\cdot}5 \times 10^7$ cells per plate), and at appropriate dilutions on minimal-plus-cystine medium and on broth agar. Control plates were made similarly from the re-suspended cells before the last centrifugation prior to treatment.

Revertant colonies, that is, colonies non-exacting for cystine, were of two main types: large colonies assumed to be due to back-mutation, and small colonies attributable to partial reversion; phage grown on the latter was able to transduce the mutant strain *cysA*-21 and other mutants of the same group to a 'small-colony' form. By analogy with similar revertants of this strain previously analysed[9], they may be interpreted as being due to suppressor mutation. The results are given in Table 1.

Table 1

	Total viable cells plated	Large-colony revertants	Small-colony revertants
Untreated	5×10^9	5	18
Treated	10^9	1,094	47,110

The counts were made after four days incubation. The total viable cell value is based upon colony counts on minimal-plus-cystine plates, since these were higher than upon broth agar.

(2) *S. typhimurium* strain *LT2* (wild type) was handled as above except that it was grown in minimal medium without cystine and plated ultimately on nutrient (broth) agar. Replica plating on to minimal medium revealed 5 auxotrophic colonies out of 1,090 printed. These were checked by re-streaking on both media and by testing for sensitivity to phage *PLT* 22 strain *H5*. All five were transducible to prototrophy by phage *PLT* 22 grown on wild-type cells. Four of these have been identified as requiring histidine, adenine, cystine and glutamic acid respectively. The fifth is not yet identified.

(3) *E. coli* strain *B* or *B/r* was grown in broth from an overnight culture to *c.* 5×10^8 cells/ml. and concentrated to 2×10^9/ml. for treatment in *M*-9 buffer. (It is necessary to use phosphate buffer since the reagent hydrolyses, albeit slowly, to give methane sulphonic acid, which is not adequately buffered by broth.) Strain *B* was treated with a 0·1 *M* solution for times ranging from 8 min. (100 per cent survival) to 15 min. (20 per cent survival) and strain *B/r* with a 0·2 *M* solution for 10 min. (70 per cent survival). Treated cells were diluted tenfold, washed, re-suspended in broth at *c.* 10^8 viable cells/ml. and aerated at 37° C. Samples were withdrawn immediately and after various times of aeration for determination of total viable count and for assay of *T6*-resistant mutants (*B/6*). For the latter purpose, samples were mixed with phage *T6*, affording a multiplicity of between 10 and 50 for 5 min. and then spread on plates each pre-spread with 10^9 phage particles, and incubated overnight at 37° C. After each 2-hr. aeration, the cultures were diluted 1 : 20 to preserve logarithmic growth. The genuineness of the putative *B/6* colonies was confirmed in a representative number of cases by replica-plating on to agar spread with 10^{10} *T6* particles/plate. The results are given in Table 2.

The experiments with strain *B* were repeated a number of times, varying the conditions, including the subdivision of the control and treated cells into a number of parallel cultures, but in all cases the result was similar. At 100 per cent survival the result was less dramatic, but the yield of mutants always rose to between 5 and 20 times the control.

Demerec[10] distrusted the procedure of growing the cells in fluid medium after treatment, on the ground that it did not permit discrimination between the progeny of early or pre-existent mutants and newly emerging mutants. Our controls indicate that there is no difference between the time of generation of wild-type and mutant, nor selection effect of a sufficient order to invalidate the procedure adopted here.

The main purpose of this article is to direct attention to the unusual properties of ethylating agents as mutagens. Their apparent uniqueness could be attributed to their extremely low toxicity which permits the use of much higher doses (from the point of view of the amount of chemical reaction sustained) than is the case with other alkylating agents. From this point of view the genetical observations present a problem to the chemist and biochemist. Our

Table 2

Time (hr.) of aeration in broth	No. of divisions (approx.)		Viable cells plated × 10^{-7}		*B/6*		*B/6* / 10^7 cells	
	Control	Treated	Control	Treated (19 per cent survival)	Control	Treated	Control	Treated
0	0	0	2·83	0·54	22	4	7·7	7·4
2	2·5	2	19·0	2·16	112	20	5·9	9·2
4	5·5	7	7·08	4·19	35	552	4·9	131
6	9	11	4·45	3·31	26	1,394	5·8	421
8	13	16	3·66	3·92	24	1,586	6·5	404
Time (hr.)	No. of divisions (approx.)		Viable cells plated × 10^{-7}		*B/r/6*		*B/r/6* / 10^7 cells	
	Control	Treated	Control	Treated (67 per cent survival)	Control	Treated	Control	Treated
0	0	0	3·24	2·16	17	27	5·2	12·5
2	2	2	14·94	8·01	55	92	3·6	11·4
4	4·5	5	3·57	3·89	22	287	6·1	74
6	9	9·5	4·93	3·42	36	2,049	7·3	599
8	13·5	14	7·32	5·60	43	2,840	5·8	489

more exclusively chemically-minded colleagues have tended to regard alkylating agents in the capacity of anti-mitotic substances as mere destroyers of deoxyribonucleic acid and have, indeed, adduced much evidence of this potentiality. In their capacity as mutagens, however, assuming, as we know to be the case with phage, that this is mediated by reaction with deoxyribonucleic acid, extensive degradation of the genetic material can play no part unless one assumes that the ultimate mutagen is a breakdown product of deoxyribonucleic acid. This is unlikely since we know, for example, in the case of bromouracil[11] that incorporation of unnatural components into deoxyribonucleic acid is itself only a pre-mutational step. The possession of a mutagen which is active at high survival-levels provides an opportunity of identifying the reactions constituting the pre-mutational step unobscured by lethal side-effects. In the case of bacteria we would like to establish whether in fact the ultimate mutation arises as a consequence of a primary reaction with deoxyribonucleic acid, leading perhaps to faulty replication at the actual site of reaction, and are considering the use of bacterial conjugation or transduction for this purpose.

From a different point of view, we feel that ethylating agents may raise chemical mutagenesis from the level of a laboratory trick to that of considerable practical importance, for example, in the field of plant breeding and industrial microbiology, and can fully agree with the words of Heslot *et al.*[3]: " . . . nous considérons que ce corps peut avoir une utilisation pratique immédiate pour l'induction expérimentale de mutations chez les plantes cultivées". A method of preparation of ethyl methane sulphonate has been described by Ross[12].

In respect of one of us (A. L.), this investigation has been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

Note added in proof. The sharp increase in toxicity of the ethyl methane sulphonate at concentrations nearing saturation reported above has now been shown to have been due to an impurity. We are unable to state the nature of this impurity, or whether it was present in the freshly prepared ester or developed on standing. It is certain, however, that the contaminant was neither an alkylating agent nor a mutagen in the systems studied. The yields of mutants given above are, therefore, valid but do not represent the maximum obtainable at the survivals indicated.

Using a more highly purified specimen it was possible to treat *B/r* with a 0·3 *M* solution for 30 min., namely 4·5 × the dose employed previously, while retaining virtually 100 per cent viability. The yield of *B/r*/6 colonies obtained after such a treatment rose to 10,740/10^7 cells plated after 15 divisions of the treated cells; controls behaved as previously.

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FOSSIL POLLEN FROM SEYMOUR ISLAND, ANTARCTICA

By LUCY M. CRANWELL*

Auckland Institute and Museum, Auckland, New Zealand

DUSÉN[1], Gothan[2] and Halle[3], who worked on plant fossils collected by the Swedish Antarctic Expedition of 1901–3, make no mention of microfossils in the material. Halle[3] explained that the mode of deposition of the plant layers in the dark, slaty Jurassic beds of Hope Bay, near the northern tip of Graham Land, precluded study of the sporangia on the fronds of a species of *Todites*, for example. Dusén[1] and Gothan[2] do not seem to have looked beyond their poorly preserved leaf and wood fragments, respectively, when dealing with the younger deposits of Seymour Island and its environs. It is from this area that I have now found pollen grains and spores—the most durable and most conservative of plant organs, as well as the most eloquent indicators of past vegetation and possible climates.

The following notes on the microflora of a small rock sample from Seymour Island are thus, so far as I can discover, among the first published records of fossil microspores from the Antarctic. Sir Albert Seward provided the first with the type of *Pityosporites*: the second has just come to hand as a list in the September report of the Australian National Antarctic Research Expeditions. These important contributions are discussed more fully at the end of this article.

Bunt[4], in his preliminary report on Macquarie Island lignites, deplores the fact that so little use has been made of pollen in studying these southern deposits. I agree with Dr. Bunt, but I do not think, as he does, that the microfossil approach has been ignored; rather, I would suggest that some of the matrices have proved recalcitrant. Where I once failed to find recognizable remains in a Kerguelen sample, Cookson[5] isolated evidence of a flora particularly rich in conifers from 'coaly' and other materials from this subantarctic island. Again, although I have just had some success with Seymour Island material, I failed in 1939 to recover either pollen grains or spores from the same rock sample.

* Present address: Geochronology Laboratories, University of Arizona, Tucson.

Fig. 1. Map showing position of Seymour Island in relation to Palmer Peninsula, formerly known as Graham Land

In view of the considerable age of the parent deposits, on which Dusén[1] and Halle[2] did not agree, and because of the dearth of information about antarctic and subantarctic plant fossils in general, it seems worth while to present a brief account of the most striking components so far noted. A fuller report will follow after further study and an exchange of opinions with others interested in plant distribution in these regions.

On Seymour Island (Fig. 1) sandstones lie at the surface, or are partly covered by huge angular blocks of basalt, whereas on nearby Ross Island and on the mainland they are hidden by the volcanics. Dusén[1] writes of coarse-grained tuff and calcareous sandstone, of some fine-grained material, and of the extreme rarity of richly calcareous material. In deciding that these fossiliferous layers are not of early Tertiary age he seems to have been most influenced by the likeness of his fossil leaves to their living counterparts, as also to magellanic fossils he had already dated as Upper Oligocene or Lower Miocene. In addition he believed strongly that a subtropical element occurred in the lowlands of Antarctica and that this antedated the spread of the Fagaceae northwards to form the so-called Fagus Stage in South America. For fifty years the Seymour Islands beds have thus been referred to as Eocene or Oligocene. Harrington[6] does not mention the area in his summary of recommended names for antarctic rock units, as his committee dealt only with East Antarctica, but he has informed me, after reading part of my manuscript, that recent work by British geologists with the Falklands Islands Dependencies Survey has shown conclusively that there is an angular unconformity on Seymour Island: the beds in the south-west are Cretaceous (Lower to Middle Campanian) while those in the north-east are probably Lower Miocene. This clears up the long-standing confusion and makes it clear that no early Tertiary deposits have been discovered.

My sample was collected by the Swedish Expedition and it is numbered 260/39 in the collections of Auckland Museum. Before sampling it looked most unpromising, being a very small, pale grey, fine-grained and weakly laminated fragment, quite unlike most of the material handled by Dusén. Only the faintest flecks of carbonized remains showed before the lamina were separated to reveal a few larger but excessively macerated leaf traces. As the matrix called for further examination, I submitted it to Prof. John W. Anthony, University of Arizona Geology Department, who describes it as "essentially a tufaceous limestone" (personal communication). A thin section showed the following minerals after leaching: calcite, quartz, plagioclase and orthoclase feldspars, and amphibole (probably hornblende), and a fairly large percentage of curved glass shards. Of this association of minerals Prof. Anthony adds: "Apparently this glass was ejected from a volcanic vent at the time the limestone was forming and it settled through water to become incorporated into the unconsolidated limestone. The other mineral fragments, together with a few of what appear to be igneous rock fragments, settled in the same way". An extremely small faunal component was noted in this section.

The attrital component, treated with a modified Schulze's solution, comprises pollen grains, pteridophyte spores, fungal teleutospores, mere traces of algae and fragments of cuticle. Preservation is sometimes excellent, but most of the pollen grains are broken or eroded, and wood and cuticles are macerated almost beyond recognition, although occasional hairs persist. Some of the larger and seemingly more fragile grains, 50μ and more in diameter, are also the best preserved. This contrast suggests a history of abrasive water-carriage, on one hand, and gentler sifting down through the air of wind-blown types to the rendezvous in coastal sediments.

As these notes will show, there is sufficient mixture of familiar floristic types to suggest derivation from varied communities, probably mainly from forest at different elevations. The high percentage of unfamiliar pollen grains in particular suggests that some types may have been washed in from older deposits.

The dominants, as indicated by the pollen, are conifers and southern beeches (species of *Nothofagus*): a similar assemblage occurs to-day all around the southern hemisphere (with the exception of the African–Madagascar region) and in montane New Guinea and New Caledonia, as Dr. van Steenis's reports[7] on the results of the Archbold Expedition recently showed. In New Zealand it has been traced as far back as the Cretaceous[8–10].

Gymnosperms: mainly podocarps and araucarians. *Araucaria* grains are mainly smaller than those described by Cookson[5] from Kerguelen deposits. *Agathis* and other furrowless coniferous types appear to be present, in a crumpled condition. Bisaccate and trisaccate grains are fairly common, ranging through the *Podocarpus – Acmopyle – Dacrydium – Phyllocladus* complex[8,11], together with allied but distinctive forms foreign to those of the living species. The phyllocladoid component is varied, the grains often being less than half the size of known living and fossil types[5,8,10]. In Fig. 2(4) is shown a *Phyllocladus*-like grain (to be described elsewhere) about 17μ in length, which has the 'spunky' bladders reminiscent of some living dacrydia. No tuberculate grains were seen. Most larger grains tie in with *Podocarpus*, *Acmopyle* and the *Dacrydia* seemingly most nearly allied to *Podocarpus*[8] [Fig. 2(2.3)]: the smaller grains seem to suggest some meeting ground between *Phyllocladus* and the second pollen group in *Dacrydium* (typified by *D. cupressinum*, *D. bidwillii*, etc.), both of which have radially strengthened bladders. Where grains are small, smooth, furrowed

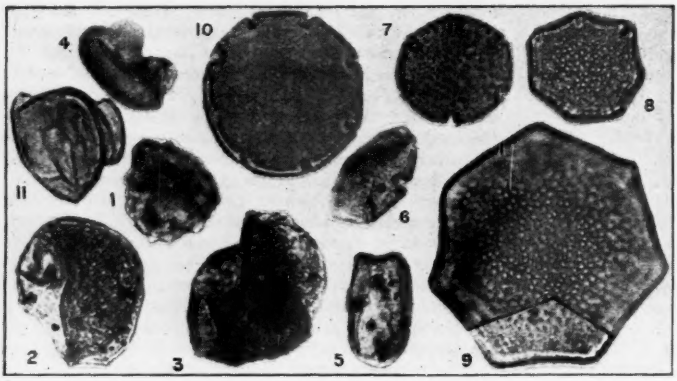

Fig. 2. Microspores: fossil from Seymour Island (1–7); living types (8–11). (*A*) *Cyathea*-like fern spore, 25μ (1). (*B*) Pollen grains: (*a*) coniferous: of *Podocarpus*-type (folded, showing one bladder, 2, 3), *Phyllocladus*, 17μ, focused on lower bladder (4), *P. alpinus*, 28μ, New Zealand, (11); (*b*) palmoid, 25μ (5); (*c*) dicotylous (6–10); *Nothofagus* pollen grains of *fusca* group, 24μ, folded in half (6), living *fusca*, 37μ, New Zealand; *N. whenua* n.sp., 18·5μ (7); *N. bernhardi*, 23μ, of *brassi* group, New Guinea (8); of *N. menziesii*, 55μ, New Zealand (9), with inset showing fissurable points on equator. (× 660–840)

and variously folded along the furrows, it is impossible at this stage to tell whether they belong to gymnospermous or palmoid types [cf. Fig. 2(5)].

Angiosperms: All the fagaceous pollen recognized falls into the first two of the three known *Nothofagus* pollen groups, as exemplified by the following living species[10,12,14]: (1) *fusca*, grain rounded in outline; exine firm, scabrate; pore rims strongly thickened; pore membranes sunken; (2) *brassi*, seemingly an intermediate type: grains usually strongly angled, often embayed between angles; rim-thickening and pore membranes reduced or lost; and (3) *menziesii*, which has larger, thinner-walled, sharply scabrate (spinulose) grains, and only vestiges of pores, their function being taken over by wide furrow-like areas (as in most species of *Quercus*) which rupture characteristically under pressure. All members of these pollen groups are anemophilous forest-formers to-day, and some form low scrub under adverse conditions. The *fusca* group is important in southern South America, Tasmania and New Zealand; in New Zealand, at least, hybridism between its members is rife[15]. Pollen of the *brassi* type was first isolated from Miocene deposits in New Zealand[12]: living species in New Guinea and New Caledonia are now known to produce pollen of this type exclusively[14].

The *menziesii* group is found to-day in cool forests of South America, and in Australia, Tasmania and New Zealand. Its fragile pollen grains occur in low frequencies in peats, etc. I have not found any in the Seymour Island material, although Dusén[1] compared fossil leaves with those of *N. obliqua*, a South American member of this group. It is to be expected that some trace of its pollen will be found somewhere between these western and eastern limits, possibly in even older deposits than those of Seymour Island. In New Zealand, Couper[10] has recorded pollen closely allied to that of *N. menziesii* as far back as the Upper Cretaceous, and he considers that his *cranwellae* type (*brassi* group of Cookson and Pike[14]) goes back to the Lower Cretaceous. This type has its oldest Australian record in the Tertiary.

All the antarctic beech pollen is small, ranging from about 14μ to 24μ. This puts it at the lowest range of *brassi*-group pollen[14]. Some grains approach the *brassi* type, but all that I have seen lack embayment of the intercolpar areas.

One very small and distinctive type, which I am naming *N. whenua*[15], may be compared with *N. bernhardi* of New Guinea, as figured by Cookson and Pike[14]. However, it has features that lead me to surmise that the *menziesii* group, despite its large size, could be a lineal descendant of this or an earlier small, sturdy, star-like grain.

Both the gymnosperms and the angiosperms of Seymour Island, therefore, suggest antiquity through their pollen record.

Various families are represented in lower frequencies, for example, Cruciferae, Myrtaceae, Proteaceae (aff. *Lomatia*, as figured by Auer *et al.*[16]), Loranthaceae (aff. *Loranthus micranthus*), Oenotheraceae (badly eroded *Fuchsia*-like grains, comparable with those of *F. magellanica*), and perhaps Winteraceae of unrecorded type. Various very small grains (9–20μ) are fairly common; they may belong to the Cunoniaceae (cf. *Weinmannia*) or the Elaeocarpaceae. Even with sub-fossil material of this nondescript type identifications are not easy.

Pteridophytes: Spores occur sparingly and are usually well preserved. The Cyatheaceae is represented by weakly trilete verrucose spores, and the Schizaeaceae by a very rare and small spore with striations reminiscent of the massive *Schizaea laevigata* spore described by Selling[17] from New Caledonia. Halle[3] reported both families from his Jurassic material.

The perfect condition of some of the very small pollen grains is of interest: it may be that abrasion is most severe when grains are greater than 10–15μ in size.

No spores of lycopods or pollen grains of Compositae, Centrolepidaceae, Restionaceae, Pandanaceae, Gramineae or Cyperaceae have been recognized. These absences seem significant. Among the unidentified types were tetrads and spiny grains, a few heavily reticulate grains, and a palmoid group already mentioned. It should be noted that the total number of microspores or fragments, per slide, is exceedingly low.

Dating: Redeposition of microspores from older beds has been noted as a possibility. This older component may well be Cretaceous: a Senonian (for example, Campanian) date does not seem excessive to me. For the younger component an upper Tertiary limit cannot as yet be hazarded: it contains types represented in early Tertiary deposits elsewhere in the southern hemisphere and seems to lack others, such as grasses, sedges and composites, which are usually present by the Miocene.

These records enrich the antarctic lists derived from megafossils. They give no evidence of the presence of *Fagus* (as reported by Dusén[1]) but emphasize instead the importance of *Nothofagus* in the antarctic background. As pollen evidence accumulates in the southern hemisphere so shrinks the *Fagus* empire postulated in the writings of von Ettingshausen, and is replaced by a condominium of southern beeches and conifers, which are still, in very similar form, compatible in cool areas to-day.

Pityosporites antarcticus: I referred earlier to Seward's controversial note of 1914[18], in which he

described a small plant body as a two-winged pollen-grain. This object was lodged in a partially decayed stem of *Rhexoxylon priestleyi* found by Sir Raymond Priestley in a boulder of Beacon Sandstone on the medial moraine of the Priestley Glacier, behind Terra Nova Bay, in Victoria Land.

Seward's interpretation of this inclusion met with such opposition, except, perhaps, from Dr. H. Hamshaw Thomas and Dr. and Mrs. Harry Godwin, that by 1933 [19] he was writing wistfully of "my unfortunate pollen grain", and pleading for his "fancy" that "Fancy with fact is just one fact the more". The opposing camp held to its view that he was probably dealing with a crushed pith cell.

Seward had instituted the genus *Pityosporites* to receive the new material (of which two examples were found), thinking that it could include other pollen grains of similar size belonging to "*Pinus* and other Abietineae". He soon decided, however, that he had over-stressed likeness to this northern group: on geographical grounds such pollen grains were more likely to have been produced by some member of the predominantly southern Podocarpaceae. Florin [20] accepted this reasoning as he writes of the grains as "possibly podocarpaceous" in his valuable paper on conifers of Chile and other southern lands. Seward, however, had pointed out that other groups known to have occurred in Antarctica could have produced these two-winged grains. The question of their identity, as of the age of the boulder, was thus left open.

If we grant, as I am happy to do, that Seward really discovered pollen grains, it is interesting to dwell further on the characteristics supplied by, or suggested by, his description and illustrations. In size (80μ) the objects are comparable with pollen grains of some living species of *Pinus* and *Podocarpus*, but come closer to the latter in the outline of the thick-walled cap, the strongly rhomboidal body, and the rather large distinctively reticulate wings, which show up best in the 1914 photomicrograph. If the sandstone in which the stem was embedded proves to be beyond the time-range of known members of the Podocarpaceae, other possibilities must be considered, and Seward has already mentioned *Glossopteris* and the Caytoniales. Concerning the former, Balme and Hennelly [21] hold that there is still inadequate proof of the discovery of microspores. Those of the Caytoniales differ from the antarctic type in their strikingly smaller size (less than 36μ, as a rule, including the wings), rounder, smaller bodies, narrower furrows, and a tendency, at least in some shown me by Dr. Jane Gray, to develop radial ("dacrydioid") wing thickenings. In addition, the body is little overlapped, if at all, by the wings. On the other hand, the antarctic grain is matched for size by microspores of *Pteruchus*, produced by pteridosperms (seed-ferns) and first described by Thomas [22] (see also Couper [23]: Pl. 26, Fig. 9) from possible Middle Triassic beds in Natal, and, among other localities, from Australia as well in the southern hemisphere by Balme and Hennelly [21]. In some examples the body is seen to be partly hidden by the wings. Illustrations have been presented in distal view, the wings appearing flat: this appearance is also characteristic of certain living species of *Dacrydium* and *Podocarpus*, the apparently flaccid wings of which are nevertheless seen to be more or less turgid if a lateral view can be obtained. Thus, after acknowledging very strong similarities to podocarpaceous grains, we come full cycle to consider whether the bodies in the pteridosperm stem (*Rhexoxylon*) may not have been pteridosperm pollen grains.

PERMIAN RECORDS: Thanks to the co-operation of Dr. H. J. Harrington (personal communication, October 19) I am able to summarize the results of very recent microspore studies of carbonaceous shale and coal from the Amery Formation, which Crohn [24] states is "regarded as the equivalent of the lithologically and structurally similar beds of the Beacon Formation". Dr. Crohn reports thirteen types and is able to assign a Permian age to these deposits: his identifications were supplied by Permian specialists at the Coal Research Section, Commonwealth Scientific and Industrial Research Organization, Sydney. Trilete spores amounted to 9 per cent, while 11 per cent were monocolpate and unwinged, and 80 per cent bisaccate, or with an encircling wing, as in the two forms of *Florinites*. Bisaccate types included high frequencies of *Lueckisporites* (distinguished by striations on the proximal (cap) side of the grain) but only 2 per cent of *Pityosporites* sp. Fuller reports will be awaited with great interest. Strong Australian and Indian affinities can be assumed from comparison with other work on Gondwanaland forms by Dr. C. Virkki in India, and by Balme and Hennelly in the Australian region.

I wish to thank Prof. Terah L. Smiley and Dr. Jane Gray of the Geochronology Laboratories, Prof. John W. Anthony of the Geology Department, and Mr. Dick Shutler, jun., all of the University of Arizona, for help of various kinds. Mr. Shutler gave me much laboratory assistance, including the running of this sample, during the past year. I have received pollen samples from Dr. George Taylor and Dr. R. A. Howard, directors of the Royal Botanic Gardens, Kew, and of the Arnold Arboretum, respectively, and I am indebted to Dr. Gilbert Archey, director of the Auckland Institute and Museum, for unfailing support of my work.

In addition I wish to thank Dr. Harrington of the Geology Department, University of New England, N.S.W., for his summaries of recently published British and Australian work, to which I could not otherwise have paid tribute in this article.

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Tuesday, December 29

Radar and Electronics Association (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7.30 p.m.—Dr. K. R. Sturley: "High Quality Sound Broadcasting".*

Wednesday, December 30

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Dr. J. D. Carthy: "Animal Senses and Reactions". (First of two Juvenile Lectures. Further lecture on January 6.)

Institution of Electrical Engineers (at Savoy Place, London, W.C.2), at 3 p.m.—Mr. G. G. Gouriet: "Colour Television". (Christmas Holiday Lecture. To be repeated on Thursday, December 31.)

Friday, January 1

Plastics Institute (in the Lecture Theatre of the Institution of Electrical Engineers, Savoy Place, London, W.C.2), at 2.30 p.m.—Dr. N. A. de Bruyne: "Sticky Plastics". (Sixth Lecture for Young People.)

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer in the Department of Veterinary Pathology—The Secretary, The University, Edinburgh (December 31).

Lecturer (preferably an experimental physicist with an interest in low temperature physics, electron resonance, or some other branch of solid state physics) in Physics—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (December 31).

Scientific Officer (with a first- or second-class honours degree in civil engineering or physics, or equivalent qualifications) at the Hydraulics Research Station, D.S.I.R., Howberry Park, Wallingford, Berks, for studies of hydraulic problems in the field of civil engineering, including scale model investigations—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting E.489/9A (December 31).

Senior Scientific Officers/Scientific Officers (suitably qualified in physics, engineering and mathematics) in the Aerodynamics Division of the National Physical Laboratory, Teddington, Middlesex, for a programme of fundamental research on problems of flight at high speeds—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.535/9A. (January 1).

Senior Lecturer in Clinical Biochemistry at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (January 4).

Advisory Officer (with a degree in agriculture or in pure science, a sound knowledge of poultry husbandry with experience of experimental work and advisory work among poultry farmers) in Poultry Husbandry—The Secretary, The North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (January 9).

Physical Chemist (with a good honours degree and suitable research experience, preferably industrial, but not necessarily in the sugar industry) in the Department of Sugar Technology, Imperial College of Tropical Agriculture, Trinidad, West Indies—The Secretary, Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2 (January 18).

Chief (with high academic qualifications and research experience) of the Division of Entomology, Commonwealth Scientific and Industrial Research Organization, Canberra, A.C.T., Australia—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 180/157 (January 23).

Babcock and Wilcox Fellow in Nuclear Engineering—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (January 30).

Lecturer in Anatomy in St. Salvator's College, St. Andrews—Joint Clerk to the University Court, College Gate, St. Andrews (January 31).

Librarian at the University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (January 31).

Senior Lecturer/Lecturer in Chemical and Extraction Metallurgy at the University of New South Wales, Australia—The Agent General for New South Wales, 56–57 Strand, London, W.C.2 (Australia, January 31).

Albright and Wilson Research Fellows in Chemistry (one at Pembroke College and one at Worcester College)—Dr. C. J. Danby, Worcester College, Oxford (February 1).

Chair of Morbid Anatomy in the London Hospital Medical College—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 1).

Chair of Physiology in the London Hospital Medical College—The Academic Registrar, University of London, Senate House, London, W.C.1 (February 1).

Lecturer in Veterinary Anatomy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, February 27).

Assistant Lecturer or Lecturer in the Zoology Department—The Secretary and Registrar, The University, Southampton.

Cell Biologist (with a degree and research experience (preferably a Ph.D.) in biology, microbiology or biochemistry), to take part in a research project on the fundamental biology of fibroblasts—Dr. J. M. Mitchison, Department of Zoology, The University, West Mains Road, Edinburgh 9.

Chair of Meteorology—The Secretary, McGill University, Montreal, Canada.

Programmer (with good mathematical qualifications, and preferably either statistical or programming experience), to work on statistical problems arising from agricultural research and surveys—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

The Water Research Association. Fourth Annual Report, 1958–59. Pp. 31+4 plates. (Redhill: Water Research Association, 1959.) [2210

Cement and Concrete Association. The Analysis of Right Bridge Decks Subjected to Abnormal Loading. By Dr. P. B. Morice and G. Little. Pp. 48. (London: Cement and Concrete Association, 1959.) [2210

Department of Scientific and Industrial Research. Report of the National Chemical Laboratory, 1958. Pp. iv+97. (London: H.M. Stationery Office, 1959.) 5*s.* 6*d.* net. [2210

Department of Scientific and Industrial Research: Forest Products Research. Record No. 30: The Natural Durability of Timber. By D. N. Smith. (Wood Preservation Series, No. 4. Second edition.) Pp. ii+26. (London: H.M. Stationery Office, 1959.) 2*s.* net. [2210

Forestry Commission. Board Mill Survey, United Kingdom—Economic Study. By Sandwell and Co. Ltd., Consulting Engineers, Vancouver, Canada. Pp. vi+70. (London: H.M. Stationery Office, 1959.) 5*s.* net. [2210

Royal Greenwich Observatory Bulletins. No. 15: Time Service 1959, January–March. Pp. 223–240. (London: H.M. Stationery Office, 1959.) 3*s.* 6*d.* net. [2210

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Other Countries

United States Department of the Interior: Fish and Wildlife Service Fishery Bulletin 154: Life History of the Sea Lamprey of Cayuga Lake, New York. By Roland L. Wigley. Pp. iv+561–617. (Washington, D.C.: Government Printing Office, 1959.) 40 cents. [2210

United States Department of Agriculture: Agricultural Research Service. Technical Bulletin No. 1202: Mormon Crickets in North America. By Claude Wakeland. Pp. ii+77. (Washington, D.C.: Government Printing Office, 1959.) 50 cents. [2210

Centro Brasileiro de Pesquisas Fisicas. Notas de Fisica. Vol. 5, No. 8: The Imaginary Part of the Optical Potential. By L. C. Gomes. Pp. 75–85. Vol. 5, No. 9: An Analysis of the Solar Daily Variations of the Primary Cosmic Radiation Measured with the IGY Neutron Monitor Network. By Léda A. de Moura, Georges Schwachheim and Erich R. Willner. Pp. 87–101. (Rio de Janeiro: Centro Brasileiro de Pesquisas Fisicas, 1959.) [2210

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LETTERS TO THE EDITORS

PHYSICAL SCIENCES

Prediction of Sunspot Numbers for Cycle 20

In a recent communication, P. Herrinck[1] has given a table of predicted sunspot numbers for the current solar cycle (No. 19), based upon the striking coincidence of values between the two periods 1749–85 and 1918–54. A good fit was obtained by multiplying figures observed 169 years before by a factor of proportion. This means, essentially, that cycles 16, 17, and 18 have been made to correspond with the cycles 169 years earlier, namely, cycles 1, 2, and 3, respectively.

It would appear that a good fit could also be obtained by making cycles 17, 18, and 19 correspond to cycles 1, 2, and 3, thus postulating the existence of a period of 180 years. The importance of this type of speculation may be seen by the fact that for a 169-year period, the maximum of Cycle No. 20 (assuming that it occurs around 1969) would be expected to be extremely low; whereas, with a period of 180 years, the maximum for Cycle No. 20 would be extremely high. Thus, it would seem that P. Herrinck is entirely correct when he states that, because of the very empirical nature of these predictions, it is essential to keep a close check with observations, and that, without theoretical support, nothing better can be expected for such long-term prediction.

W. B. Chadwick

Central Radio Propagation Laboratory,
Boulder, Colorado.
Sept. 24.

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Telluric Origin of the Whistler Medium

It has recently become apparent that the ionized medium surrounding the Earth and responsible for the transmission of radio whistlers must be of telluric origin. When radio whistlers were first explained by Storey[1], and it was shown that concentrations of several hundred electrons per c.c. existed at distances of several Earth-radii from the Earth's centre, it was rather generally accepted that the medium must be of solar or interplanetary origin, as it did not seem possible to conceive any extension of the Earth's atmosphere to so high an altitude. Arguments are presented here to show that the medium cannot be of solar or interplanetary origin, and a mechanism is suggested for a telluric origin of the medium.

The most common conception of the whistler medium is probably that it consists of ionized solar gas from an extreme extension of the solar corona or from the solar wind which has in some way penetrated the Earth's magnetic field and become trapped in the same manner that the Van Allen radiation is trapped. This requires that the particles possess a specialized velocity distribution, as particles with velocities oriented along or nearly along magnetic field lines will not be trapped, but will flow into the ionosphere and be lost from the medium. Owing to the prevalence of hydrogen in the solar system, the medium must be expected to consist mainly of protons and electrons in equal numbers if it is of solar or interplanetary origin. The protons would be expected to have an energy of about 10 keV. if they originate in the solar wind, and 20 eV. if they originate in an extended solar corona of the type described by Chapman[2]. A whistler medium consisting of such high-temperature solar gas would cool rapidly to the temperature of the Earth's exosphere, due to the presence of a cloud of neutral atomic hydrogen which surrounds the Earth and extends out from the Earth for a distance of several Earth radii. This hydrogen corona, which was first discussed by Chapman[3], originates through the photo-dissociation of water vapour and methane[4] near an altitude of 80 km. Its distribution and concentration around the Earth have been discussed by Singer[5] and by Johnson[6].

The temperature of the hydrogen corona is the same as that of the upper ionosphere and exosphere, and the value indicated by the rate of orbital decay of the Vanguard satellite, 1958β 2, is about 1,250° K[7]. The manner in which the cooling occurs is by charge exchange between the energetic protons and the thermal hydrogen atoms, yielding thermal protons (1,250° K.) and energetic hydrogen atoms which escape from the vicinity of the Earth. The cross-section for the charge-exchange reaction has been measured[8] for protons with energies up to 20 keV. Combining the cross-section data and the hydrogen-density data, it is found that the lifetime of an energetic proton, for any energy up to 20 keV., is about 1 day[9] for the lowest hydrogen density values which have been proposed, and much less for the larger values. Thus, a solar proton cloud trapped in the Earth's magnetic field would cool to a temperature of 1,250° K., with a time constant of about 1 day or less.

A cloud of thermal protons cannot remain trapped in the magnetic field as a cloud of high-energy protons can. This results from the fact that the collision cross-section is relatively large at temperatures as low as 1,250° K., and collisions are, therefore, rather frequent. Even for concentrations as low as 300 particles cm.$^{-3}$, the collision frequency is 300 day^{-1}. Collisions occurring this rapidly cause the velocity distribution to become isotropic, thus disturbing the specialized distribution of velocities required to maintain the particles in trapped orbits. As a result, there is a flow of protons from the whistler medium into the ionosphere. If we assume a concentration of 10^3 protons cm.$^{-3}$ throughout the whistler medium, we will under-estimate the rate of loss and over-estimate the total number of protons contained within the whistler

medium. The total number of protons within a magnetic shell intersecting the Earth's surface at 45° latitude is then 4×10^{30}. The rate of flow of protons into the ionosphere within this magnetic shell is 4×10^{26} protons sec^{-1}. Thus, the protons flow into the ionosphere at such a rate that the medium would become exhausted in 10^4 sec. or much less than one day, if the flow continued undiminished. On reaching the ionosphere, the protons can be expected to become neutralized by charge exchange with atomic oxygen or by direct recombination, thus becoming permanently lost from the medium.

In order to make the solar-origin theory acceptable, it is only necessary to suggest that the injection-rate equals the loss-rate discussed above. However, it is not possible to accept such rapid injection, and this is shown by the decay of the shell of *Argus* radiation[10]. Electrons released during the third *Argus* atom bomb burst at high altitude formed a shell around the Earth. The shell was about 150 km. thick at half maximum (± 30 per cent), and showed no broadening during its lifetime. It lasted about two weeks and was stationary during the entire period, any motion which may have occurred not exceeding 2 km. day^{-1}. This shows that the magnetic field, over that period of time at any rate, was not disturbed to an extent sufficient to permit trapped particles to cross the magnetic shells. Thus, the stability of the *Argus* shell shows that the whistler medium, if it consisted of trapped solar protons, would have entirely disappeared within the *Argus* shell during the period of time that the *Argus* shell persisted. Such disappearances of the whistler medium are not observed, hence it must be accepted that the medium is not formed by the trapping of solar protons.

It has been suggested[11] that the existence of an insulating layer between the ionosphere and the Earth permits mixing of the magnetic tubes of force and the plasma trapped in them to take place in such a way that very high energy particles such as those in the *Argus* shell would not be disturbed. Although the effect is based on sound physical principle, the required conditions are not well satisfied for the whistler medium, as the tubes of force in which the whistler medium is contained are in effect anchored in the lower ionosphere. The tubes can move only if all the ionized material within them down to the insulating layer moves also. In order to replace the whistler medium within the *Argus* shell in one day's time, an average rate of flow in and out of the *Argus* shell of more than 100 metres sec.$^{-1}$ would be required in the ionosphere. Such motion of magnetic field and ions in the ionosphere would involve a great dissipation of energy through collisions between the moving ions and the stationary neutral particles. The dissipation in the *F*–1 region would be an appreciable fraction of the total energy input into the ionosphere in ultra-violet radiation, which is about 5×10^{-8} watt cm.$^{-2}$. An energy source of equivalent power would be required to drive the magnetic mixing, and no such driving mechanism has been conceived. Solar heating in the equatorial regions is not effective as a driving mechanism, because solar energy is unable to account fully even for the warmth of the *F*–2 region, and cannot give rise to any convective-like instability. It must be concluded, therefore, that such mixing of tubes of force does not occur at temperate and low latitudes, because of the natural stability of the medium[11] and because of the lack of a driving mechanism.

If any solar-origin theory must be abandoned because of the eventual loss of the protons into the ionosphere, it appears that the place to look for the origin of the whistler medium is in the ionosphere itself. As pointed out by Dungey[12], there is a nearly resonant charge-exchange reaction between hydrogen atoms and oxygen ions. Collisions between atoms and ions are important up to the base of the exosphere, which is at an altitude of about 550 km., and the charge-exchange reactions occurring near this altitude govern the concentration of protons at this altitude and above[13]. The cross-section for the charge-exchange reaction merely governs the rate at which equilibrium concentrations are established, and does not affect the equilibrium concentrations themselves. The reaction, therefore, gives rise to some concentration of thermal protons near the base of the neutral particle exosphere at 550 km. Above this altitude, the protons are distributed according to a hydrostatic law, and extend up into the region which constitutes the whistler medium. It is not at this time possible to advance an entirely quantitatively satisfactory theory, because of lack of knowledge of the required reaction cross-sections and of ion and neutral-particle concentration data. However, it appears that the $H + O^+ \rightarrow p + O$ charge exchange reaction near the base of the exosphere must be responsible for the formation of the whistler medium.

Since the whistler medium is of telluric rather than solar origin, whistler data cannot be considered indicative of conditions in planetary space.

Francis S. Johnson

Lockheed Aircraft Corporation,
Missiles and Space Division,
Sunnyvale,
California.

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A Relation Between Giant Travelling Disturbances and Sporadic *E* Ionization

For some time it has been suspected that a correlation may exist between *F* disturbance phenomena and sporadic *E* ionization. Munro[1] failed to find any association between E_s and 5·8 Mc./s. fixed frequency disturbances but this type of disturbance is small in magnitude and recent examination of ionosonde records shows that quite often an anomaly in E_s ionization is associated with giant travelling disturbances[2].

During the winter months when occurrence of sporadic *E* is not normally prevalent this usually takes the form of temporary appearance of E_s where none was previously present. Correlation is not 100 per cent, and quite often large *F* disturbance anomalies are not associated with a corresponding E_s effect, or E_s appears and no associated *F* disturbance is evident, although in this case it is suspected that appearance of strong E_s often blankets a simultaneous complexity in the *F* trace.

Ionosonde records for the period July 10, 1955–July 28, 1955 inclusive have been studied, and in the many examples found the changes are too significant for the association to be fortuitous.

A typical example of a large travelling disturbance occurred on July 18, 1955 appearing consecutively on ionospheric records at Hobart (42°53′S., 147°51′E.), Canberra (35°18′S., 149°E.), Sydney (33°52′S., 151°11′E.), and Townsville (19°10.S., 146°58.E.).

The times of occurrence of the anomalies on the various ionosonde records were consistent with a disturbance travelling 22° east of north with a speed of 7·6 km. per minute. There was a related E_s effect at each station and, moreover, there was no appearance of E_s on the records for some hours before these times. A similar F disturbance on the same day occurred first at Hobart at 1054 hr., arrived at Canberra at 1246 hr. and at Sydney at 1300 hr. There was an associated development in E_s at each station and the F disturbance was travelling 10° east of north with a velocity of 9 km. per min.

Again, on July 23, 1955 another giant travelling disturbance moving due north with a speed of 7·5 km. per min. left Hobart at 11.30 hr. arriving at Canberra at 13.20 hr. and Sydney at 13.44 hr. This was accompanied by the development of E_s at all stations which was particularly intense at Canberra at 13.40 hr. and Sydney at 1410 hrs.

Evidence is accumulating that sequential E_s as described by McNicol and Gipps[3] is also related to travelling disturbance phenomena. The anomaly appears as a stratification of the base of the F_1 layer which leads to the formation of an E_2 layer at about 150–200 km. in height. This layer then moves slowly downwards intensifying as it does to form E_s ionization at 100–110 km. Many examples have been found of the original stratification in the F_1 region being due to travelling disturbance phenomenon which is first evident as a complexity at the top of the F_2 or F_1 trace and then progresses to the lower regions of the ionosphere.

Munro and Heisler[4] have attributed the F_2 cusp type anomaly to modification of ion distribution during the passage of a disturbance and recent work at this Laboratory suggests that during the first phase of the disturbance there is a downward transport of ionization, and appearance of E_s is always associated with this. The simultaneity of E_s and F events would imply that such movement of ionization must occur in the ionosphere as a whole and could be either due to an electric field or vertical movement of the neutral air mass. Moreover, since the F_2 disturbance is a transient phenomena it would appear that two mechanisms are involved, one which produces the F_2 disturbance and E_s and another which maintains E_s ionization sometimes for some hours after it is produced.

This work forms the subject of a totally new concept of formation of E_s. Research is continuing in an effort to elucidate the mechanisms involved and it is intended to publish a complete paper at an early date.

L. H. HEISLER

Radio Research Board Laboratory,
Electrical Engineering Department,
University of Sydney.

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Condensation Processes for the Extraction of Radioactivity from Air

A NUMBER of natural and artificial radioactive elements are known to exist in the atmosphere. The active atoms, other than those which form gases, get attached to aerosols present in the air flow and can be collected on filters capable or retaining the aerosols. The filters generally used for this purpose are: (1), mechanical and (2), electrostatic. Mechanical filters, if made efficient for retaining fine aerosols (of dimensions 0·01μ), have large resistance to air flow; hence it is difficult to process large amounts of air and therefore to measure weak activities. Electrostatic filters have negligible resistance to air flow and are efficient for retaining fine particles up to $\sim$ 0·01μ. Their efficiency for still smaller sizes decreases because of the difficulty of charging very fine aerosols.

Investigations are being conducted in this laboratory on radioisotopes produced by cosmic rays in the atmosphere, and it is of interest to determine their concentrations in various air masses. The concentration of these in air is very small, and hence it is necessary to process large amounts of air to collect detectable activities. Further, it is possible that a considerable fraction of these isotopes might exist on very fine aerosols. Therefore, there is need for a method which can remove very fine aerosols and has negligible resistance to air flow. An attempt in this direction was made by passing air through an air-conditioning coil and condensing some of its moisture on cold fins. It was found that the water vapour was removed efficiently from the air but not the radioactivity. It may be that in this case the water vapour condenses directly on the cold fins and not on fine aerosols. The experiments described below were designed to ensure that condensation occurred on the aerosols.

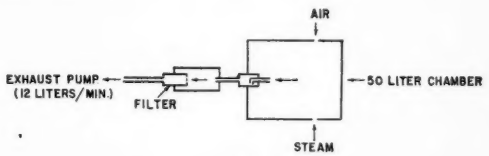

Fig. 1

Exp. 1. Steam and air were mixed in a glass chamber as shown in Fig. 1. The water droplets mostly settled on the walls of the chamber. A baffle was used to remove the droplets almost completely. The amount of water vapour which condenses as water droplets is much smaller than the amount of steam introduced and can be calculated.

After undergoing condensation, the air was passed through a filter paper (Hollingsworth and Vose, or Whatman No. 42). To avoid wetting the filter paper, the air temperature was raised by a few degrees centigrade before it entered the filter. The gross β-activities of the condensate and of the filter paper were measured on an end-window beta-counter. The results obtained are given in Table 1.

Exp. 2. The walls of the glass chamber containing air were continuously cooled and atmospheric air was drawn through it. Cloud formation occurred as a result of the atmospheric air mixing with the cold air in the chamber. Results similar to those of Table 1 were obtained.

In both methods, the resistance to air-flow is negligible. The degree of supersaturation is enough to cause condensation on aerosols of size down to 0·01μ.

Table 1

Steam introduced in 1 m.³ air	Liquid condensed as cloud in 1 m.³ air (calc.)	Activity in condensate (counts per min.)	Activity on filter paper (counts per min.)	Efficiency with respect to filter paper
500 gm.	11 gm.	27·8 ± 1·7	0 ± 0·3	1·0
500 gm.	11 gm.	15·8 ± 1·3	0·5 ± 0·2	0·97
350 gm.	9 gm.	13·8 ± 1·4	0·9 ± 0·2	0·94
180 gm.	8 gm.	11·0 ± 0·7	0·7 ± 0·2	0·94
100 gm.	6 gm.	10·4 ± 0·8	3·9 ± 0·4	0·73
100 gm.	6 gm.	8·0 ± 0·6	2·9 ± 0·3	0·73

Room temperature ~35° C.
Amount of air used in each experiment ~5 m.³

The still smaller aerosols are also efficiently removed since they get attached quickly to cloud droplets through Brownian motion. However, it may be desirable to cause condensation directly on the smallest aerosol by expanding the saturated air adiabatically. This is being done at present. It is clear that these condensation processes can be used to remove radioactivity from large quantities of air with a high degree of efficiency.

I am indebted to Prof. B. Peters and to Prof. M. G. K. Menon for their interest and encouragement during this experiment. I am also grateful to Mr. A. Subramaniam for useful discussions.

Rama

Tata Institute of Fundamental Research,
Apollo Pier Road,
Bombay, 1.
Sept. 9.

Plasma Heating by Current-Saturation

Several attempts have been made (for example in *Zeta*[1], *Sceptre*[2], *Perhapstron*[3], etc.) to produce high-temperature plasma in a toroidal discharge by means of large induced currents. These experiments have shown that Joule-heating of the plasma by the induced electron current is inefficient. Increasing this current alone does not seem to be sufficient to produce the required high-temperature plasma for controlled fusion. On the other hand, it is observed in toroidal discharges that acceleration of ions takes place, as indicated by the anisotropy of neutron distribution[4] and by the Doppler shift of spectral lines[5]. Ion acceleration is possible[5] when ion-electron collision cross-section becomes small, a condition which sets in when the electrons begin to 'run away'.

Early estimates for the 'run away' condition[6] did not take into account the possibility of processes[7] that create this condition. Recent estimates[8] of the rate of production of 'run away' electrons show that large current densities due to 'run away' electrons can be built up within a fraction of a millisecond after the initiation of the discharge. (It may be pointed out that in the light of these experimental results and theoretical possibilities, it does not seem justified to use the usual arguments[9] to show that 'run away' cannot take place in these discharges. These arguments, which are applicable only to conservative systems[10], do not represent conditions in these discharges). Thus suitable conditions are created for acceleration of ions which produce neutrons in a deuterium discharge. These neutrons have been called 'false' or 'wrong' neutrons. Nevertheless, a high-temperature plasma which is in thermodynamic equilibrium may not be achieved in these discharges where the energy density of the applied electromagnetic field is even comparable with that of the plasma.

It is suggested here that the process which produces 'run away' ions may be exploited to increase the energy density of the plasma even though such a plasma is not in thermodynamic equilibrium. If one tries to increase the number of 'run away' ions by increasing the duration of the discharge or the magnitude of the applied field, the corresponding total current, which is mainly the electron current, becomes very large, with accompanying losses in the primary circuit and the magnetic cores. These losses could be reduced if the electron current could somehow be limited.

In a transformer when the primary current, say, increases, the secondary current also increases. In ordinary practice, there is a large number of electrons in the secondary conductor and the comparatively small velocity of the electrons, as determined by their mobility, is sufficient to satisfy the demand for current in the secondary. But, a secondary can be visualized, as in a toroidal discharge, where the number of available electrons is comparatively small. An increased demand in the secondary current can be satisfied only by the increase in velocity of the electrons. Now, if the current in the primary is continuously increased, the secondary current density, nev tends to an upper limit nec, where n is the number of electrons per cm.^{3}, e is the electronic charge and v is the velocity of the electrons, which tends to the velocity of light, c. Under this condition, the electron-ion collision cross-section[11], which is proportional to e^2/mv^2, rapidly decreases and the electron current tends to become decoupled from the ions, leaving the ions comparatively free to be accelerated. A situation can then be realized, if sufficient time is allowed, when, say, about half the ions 'run-away' and become accelerated to energies of several thousand electron volts and produce nuclear reactions with the slowly moving ions. Such an assembly of ions is somewhat equivalent to a one-dimensional gas at a very high temperature. It may not be possible to achieve this condition in the present machines. For example, in *Zeta*, with about 6×10^{16} electrons per cm. length of discharge, the saturation electron current would be about 3×10^8 amp., which is about a thousand times the actual current.

It should be emphasized that in this scheme the highly pinched relativistic electron beam[12] suggested for high-energy accelerators is not essential.

Calculations on some of the problems, such as the time for current saturation and ion acceleration, the requirements of the magnetic and electric fields, and the nuclear reaction-rate will be published elsewhere.

K. A. George

Tata Institute of Fundamental Research,
Bombay-1, India.
Sept. 22.

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An Improved Cæsium Frequency and Time Standard

PRELIMINARY measurements have been completed with the longer and more precise standard mentioned at the conclusion of our earlier work[1]. The beam chamber, including the diffusion pump, is 5·2 m. long and the distance between the cavity resonators in which the transitions are excited is 2·77 m. The width of the resonance curve is 52 c./s. and at the resonance frequency of approximately 9,200 Mc./s. this corresponds to a Q factor of $1{\cdot}8\times10^8$. The theoretical line width is 55 c./s., given by the formula $\Delta F=0{\cdot}65\ \alpha/L$, where α is the most probable velocity of the atoms and L is the distance between the cavities. The difference between the experimental and theoretical values could easily be due to some velocity selection. The resonance curve is reproduced in Fig. 1, in which the experimental points are individual measurements. They illustrate the steadiness of the conditions and the signal-to-noise ratio. The pressure was 3×10^{-7} mm. mercury, and was obtained after 2 days pumping with a 9-in. 3-stage fractionating oil-diffusion pump, and with the help of liquid-nitrogen traps.

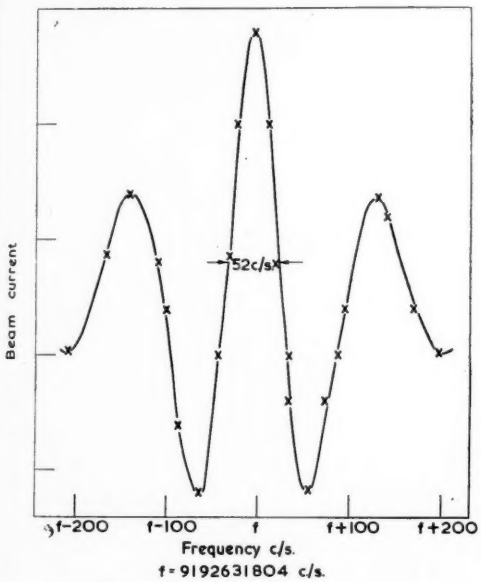

Fig. 1. Experimental resonance curve

The frequency of the peak is 9 192 631 804 c./s., where the 'second' is 9 192 631 770 cycles of the cæsium F,m (3,0)↔F,m, (4,0) transition at zero field[2]. The field was rather large and non-uniform, and it is estimated that the calculation of the field correction under these conditions can only be made to ±2 parts in 10^{10}. The correction obtained is 32 c./s. and the new standard thus confirms the value already adopted within the experimental limits. A new magnetic screen is being made to give a small uniform field, and it is expected that the amplitude of the signal can also be increased. The purpose of the present communication is simply to indicate that a standard having a precision of a few parts in 10^{11} is quite practicable.

The general features of the design were prepared by Mr. J. V. L. Parry and the instrument was made in the Standards Division Workshop from drawings prepared by Mr. D. C. Barnes. The standard has been put into operation by Dr. L. Essen and Mr. D. E. Sutcliffe has assisted with the experimental work. The work has been carried out as part of the research programme of the National Physical Laboratory and this communication is published by permission of the Director of the Laboratory.

L. ESSEN,
National Physical Laboratory,
Teddington, Middlesex.

J. V. L. PARRY
United Kingdom Atomic Energy Authority,
Capenhurst, Near Chester.
Sept. 22.

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METEOROLOGY

Potassium/Sodium Ratio in Rainwater

IN a recent article Dr. A. T. Wilson[1] notes that 'the potassium/sodium ratio in rainwater is often larger by a factor of 10 than that in the sea—the obvious source'. His explanation is that most of the sea water transferred to the atmosphere in the form of spray is derived from a very thin surface layer of the sea, which is rich in potassium and nitrogen as a result of the activities of micro-organisms.

Low values of sodium/potassium ratio (to put it in a more convenient form) in rain water are commonly recorded in Europe and the United States, but it seems very unlikely that, in these regions, they are caused in the manner suggested. For, in fact, they are scarcely ever observed at exposed coastal stations. The more maritime the situation of a station is, the more closely does the ratio approximate to that of sea water in bulk, that is, 27. Lerwick, in the Shetland Islands, is the most completely exposed station in Europe, and there the ratio has averaged 24 during the 17 months for which records are available, and has never fallen below 18. Really low values invariably occur inland.

The decline in the ratio with increasing distance from the sea is surprisingly rapid, and even in southern Sweden, at places less than 200 km. from the sea, its value is no more than 1·7[2]. This seems to be as low as it goes: Larsson and Hettick[3] found that it averaged 1·8 at Illinois in the heart of the United States. It seems a reasonable inference that the direct influence of the sea is confined to quite a narrow coastal belt. Inland, the majority of the sodium and potassium brought down by rain is in all probability derived partly from the combustion of fuels and partly from the land itself. No doubt this is true of other elements also, and it is a point which needs to be borne in mind when assessing the agricultural value of the mineral content of rain water.

B. C. V. ODDIE
Meteorological Office,
Air Ministry,
Kingsway,
London, W.C.2.

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GEOLOGY

Anomalous 'Common Strontium' in Granite

The term 'common strontium' is customarily used to denote the element as found in minerals with high ratios of strontium to rubidium. These include strontium-rich minerals such as celestite and also many common rock-forming minerals containing strontium in the parts per million concentration range. All analyses reported so far, with the single exception of meteoritic strontium, indicate that the isotopic abundances of common strontium are constant to within a few per cent. In particular, no significant increase has been found in the world-wide strontium-87 abundance due to the continual addition of radiogenic strontium with time[1], nor has any case been previously reported of strontium-87 enrichment due to local mixing with radiogenic strontium. In this communication, we wish to cite an instance of local strontium-87 enrichment: two common strontium minerals isolated from a Precambrian granite at Boya near Perth, Western Australia, show strontium-87 abundances some 8 per cent higher than the 'normal' value, while the common strontium for the granite as a whole is apparently some 15 per cent higher.

The discovery was made through attempted strontium/rubidium age determinations on biotite, microcline and 'total rock'[2] samples of the granite using the normal figure for strontium-87 abundance (7·0 atom per cent = 0·71 strontium-87/strontium-86) to correct for common strontium. The average ages calculated on this basis, together with the calculated ratio of radiogenic to common strontium-87, are shown in Table 1.

Table 1. Mineral Ages Using 0·71 as Strontium-87/Strontium-86 in Common Strontium

Material	Radiogenic ^{87}Sr / Common ^{87}Sr	Age (million years)
Biotite	1·75	650
Microcline	0·31	1290
Total rock	0·17	2430

For individual samples, this pattern of increasing age with increasing common strontium content, was reproducible to better than 10 per cent. Both the microcline and the total rock samples contain relatively large amounts of common strontium. As a result, their ages were very sensitive to the value assigned to the common strontium 87/86 ratio. In a graph relating the ratio radiogenic strontium-87/rubidium-87 to variations in the common strontium 87/86 ratio (Fig. 1), it was found that the three straight lines representing the three age determinations intersected approximately at a point, corresponding to an 87/86 ratio of 0·82. If this figure is used in correcting for common strontium, the biotite, microcline and total rock samples will give a concordant age of about 520 million years.

The presence of anomalous common strontium was confirmed by analyses of epidote and apatite concentrates from the original granite sample. The ratio strontium/rubidium in the epidote was about 45; no rubidium could be detected in the apatite. Both possessed strontium-87/strontium-86 ratios of 0·77. Even though this value is significantly lower than predicted for complete age concordance, it is sufficiently anomalous to indicate a partial mixing of radiogenic with common strontium.

We believe that the correct interpretation of the age data is that the granite crystallized at least

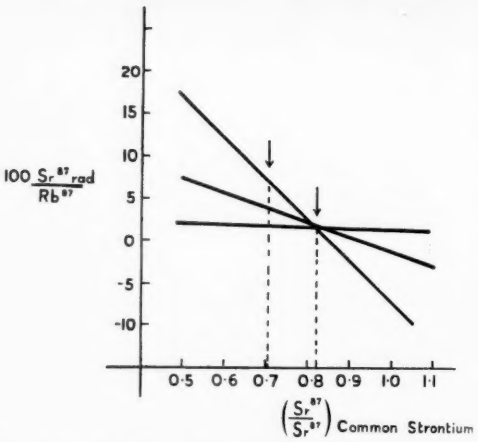

Fig. 1. The ratio radiogenic strontium-87/rubidium-87 as a function of common strontium strontium-87/strontium-86 ratio

2,400 million years ago (corresponding to the total rock age and using the 'normal' strontium-87/strontium-86 ratio for common strontium), but at about 520 million years ago it was metamorphosed. At this time, some or all of its minerals were reconstituted: radiogenic strontium left the biotite and potassium feldspar, to be partially or completely mixed with the original common strontium in other minerals. Apparently the granite as a whole remained a closed system with respect to rubidium and strontium throughout its lifetime, including the period of metamorphism. Independent evidence for a 2,400 million year event was given by concordant muscovite and feldspar strontium/rubidium ages. These minerals occurrred in a pegmatite dyke cutting the same granite at a place several miles distant. The biotite in the granite here also registers the 520 million year reconstitution. Presumably the much coarser grain size of the pegmatitic minerals was responsible for their apparent complete retention of radiogenic strontium during the metamorphism.

Geological evidence for the metamorphism cannot be seen in hand-specimens of the granite, but in thin section, strain quartz, moderately decomposed feldspar (epidote, sericite), and slightly chloritized biotite provide evidence for stress or reheating. Regionally there has been widespread injection of dolerite dykes, as yet undated. These are probably associated with the metamorphism of the granite, but they themselves cannot be directly responsible since we have lately found precisely the same discordant biotite and total rock ages in a granite situated about 100 miles distant where the occurrence of dolerite dykes is very rare.

It is evident from this study that the clearest distinction must be made in radioactive age determinations between mineral age and the age of original crystallization of the whole rock. An isolated determination by the strontium/rubidium method using the biotite from a granite yields the biotite age only, which is by no means necessarily the age of emplacement of the granite. Knowledge of the relationship between these two ages requires at least one further analysis: preferably another age determination using a total rock sample, or else a measurement of the common strontium strontium-87/strontium-86 ratio for the particular granite under investigation.

Details of the age determinations cited here will be published elsewhere. We are indebted to Dr. A. F.

Wilson of the Department of Geology for advice and assistance, and to the Carnegie Institution of Washington for financial support.

W. COMPSTON
P. M. JEFFERY

Department of Physics,
University of Western Australia,
Nedlands.
Aug. 17.

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Rubidium-Strontium Ages of Lewisian Rocks from North-West Scotland

THE Precambrian crystalline basement of north-west Scotland, the Lewisian, has been described by various authors[1,2]. Sutton and Watson[3] defined two distinct metamorphic episodes in the Lewisian, the Scourian and the later Laxfordian, both of which occurred before the deposition of the Precambrian Torridonian Sandstone. The absolute age of these Precambrian rocks has not been determined, however.

In 1955, Holmes *et al.*[4] reported the first isotopic age measurements on Lewisian rocks. Measurements on eight feldspars, all from pegmatites, were made by the potassium-argon method. Three samples came from the Outer Hebrides, three from the Laxfordian, and two from the Scourian. Omitting three samples which were suspect on geological evidence (visible alteration or proximity to nearby dykes of unknown age) an average age of 1090 ± 70 m.y. (million years) was given as representing the late stages of the Laxfordian. The ages obtained, however, were subject to two errors not known at the time. The decay constants for potassium-40 have recently been remeasured[5,6], and using the newer values ($\lambda_\beta = 4{\cdot}72 \times 10^{-10}$ yr.$^{-1}$ and $\lambda_e = 0{\cdot}585 \times 10^{-10}$ yr.$^{-1}$) two Laxfordian samples give ages of 890 and 870 m.y. (The other Laxfordian and the two Scourian samples were the ones considered suspect.)

The second, and more important source of error is the loss of argon from feldspars in the course of geological time. Thus, any potassium-argon date on feldspar is a minimum figure and may be as low as only half the true age[7,8]. The measurements of Holmes *et al.* therefore cannot be considered to have dated the Laxfordian unequivocally, but did show that several Lewisian pegmatites were at least 870 m.y. old.

It has recently been shown that under certain conditions some feldspars may behave as closed systems with regard to rubidium and strontium during metamorphism of an already crystalline basement[9]. The rubidium-strontium method may therefore yield relict ages of the earlier crystallization. This suggested a possible means for dating both the earlier Scourian metamorphism (by using feldspars from areas little affected by the Laxfordian) and also the Laxfordian itself.

An isotope dilution technique for determining the rubidium and strontium concentrations and the strontium isotopic composition in the purified mineral was employed and will be described elsewhere. Isotopic analyses were made with a Metropolitan-Vickers *MS*-5 solid source mass spectrometer, which has a 90°, 12 in. radius of curvature analyser tube and an electron multiplier for detecting the ion beam. The rubidium-87 half-life was taken as $5{\cdot}0 \times 10^{10}$ years[10].

The analytical results and calculated ages are given in Table 1. The errors on the ages are those resulting solely from the analysis and do not include uncertainties due to half-life or geochemical alteration. Two biotites and a potassium feldspar from Laxfordian rocks, and one feldspar from the Scourian were measured. The Scourian pegmatite feldspar gives an age of 2,730 ± 30 m.y. while the minerals from the two Laxfordian localities average 1,440 ± 30 m.y. (weighting each by the analytical error). One biotite is from the gneiss itself, whilst all the other samples are from pegmatites. The Laxfordian feldspar has a very high normal strontium content (643 p.p.m.) which introduces a large uncertainty in the age obtained.

Table 1. RUBIDIUM-STRONTIUM AGES OF LEWISIAN ROCKS, NORTH-WEST SCOTLAND

Sample Description	Mineral	Rb (p.p.m.)	Sr Normal (p.p.m.)	Age (m.y.)*
Laxfordian gneiss	Biotite	566	29·2	1420 ± 30
Laxford Bridge		566	28·5	1340 ± 30
Laxfordian pegmatite 2·3 mls. N. of Laxford Bridge	Biotite	500	30·0	1480 ± 30
	Feldspar	323	643	1530 ± 200
Scourian pegmatite 2 mls. S. of Scourie	Feldspar	759	151	2670 ± 50
		752	172	2740 ± 40
		746	152	2770 ± 40

* Duplicate analyses shown represent completely separate determinations starting each time with the pure mineral. The rubidium-87 half-life was taken as $5{\cdot}0 \times 10^{10}$ years.

The older feldspar comes from a pegmatite (π_1 of Fig. 6, Sutton and Watson[3]) that is cut by a dolerite dyke which is in turn cut by a Laxfordian pegmatite, thus providing evidence for the Scourian age of the feldspar. The rubidium-strontium dates therefore confirm that the Scourian metamorphism is indeed a distinct event separated in time (by about 1,200 m.y.) from the Laxfordian, as Sutton and Watson suggested.

An age of 2,730 m.y. or greater is indicated for the Scourian and, therefore, for the primary Lewisian basement. The Laxfordian metamorphism probably occurred at about 1,440 m.y. ago. If so, the Torridonian is less than 1,440 m.y. old.

One of the Scourian feldspars reported by Holmes *et al.*[4] (1251-*A*) is probably from the same pegmatite as the one given here. Recalculation with the newer potassium-40 decay constants gives this an age of 640 m.y. as compared to the rubidium-strontium age of 2,730 m.y. It is probable that later heating effects of the intruding dolerite dyke and/or Laxfordian metamorphism expelled the argon which had built up in the mineral previously. An alternative explanation requires an abnormally low argon retention (12 per cent). The rubidium and strontium, however, were retained more effectively, perhaps completely.

Of broader interest is the discovery of a very ancient terrain, at least 2,700 m.y. old, in the European basement at its western margin. The presence of very old rocks at the margins of the European continent in Scotland and the Kola Peninsula of the U.S.S.R.[11] may be more significant than the possible occurrence of a more centrally located old terrain. Further analyses are in progress to find whether these dates are generally representative of Lewisian rocks in north-west Scotland, including the Outer Hebrides.

I wish to thank Prof. L. R. Wager for encouragement and useful discussions, and Prof. J. L. Kulp, Dr. R. St. J. Lambert, and Mr. S. Moorbath for careful criticism of this communication. Dr. Lambert kindly supplied the specimen of Scourian feldspar.

This work forms part of a programme of geological age determination being carried out in the Department of Geology and Mineralogy, Oxford, under the direction of Prof. L. R. Wager and Dr. E. A. Vincent, with financial assistance from the Colonial Development and Welfare Fund and the Department of

Scientific and Industrial Research. The strontium-86 and rubidium-87 tracers were supplied by the United Kingdom Atomic Energy Research Establishment, Harwell.

Bruno J. Giletti

Department of Geology and Mineralogy,
University Museum,
Oxford.
Aug. 25

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METALLURGY

Spectrographically Pure Metals

Much research work is now being carried out for which metals of the highest degree of purity are desirable. In recent years advertisements or quotations have been received from several sources offering so-called 'pure', 'spectroscopically pure' or 'spectrographically pure' metals, and spectrographic reports have been given suggesting a high degree of purity. Subsequent correspondence has revealed that the reports referred to metallic impurities only, and that non-metals, notably nitrogen, oxygen and carbon, were ignored completely, although some were present to extents far greater than those of the metallic impurities for which the details were given. To those unfamiliar with the subject, a spectrographic report alone may give a quite misleading impression of the purity of a metal, and the importance of obtaining a complete analysis should be emphasized.

W. Hume-Rothery

Department of Metallurgy,
Parks Road, Oxford.
October 23.

CHEMISTRY

Mechanism of Anti-Knock

There are two theories of the mechanism of anti-knock, one depending on heterogeneous and the other on homogeneous reactions.

The heterogeneous or 'smoke' theory of Muraour[1] is supported by Walsh and his collaborators[2,3], on the basis of their studies of the low temperature oxidation of ethers in coated vessels. The reactions leading to auto-ignitions in the end gas are supposed to be inhibited by removal of chain centres at the surface of the particles.

In view of the very small quantity of lead tetraethyl that is included in gasolines, Egerton[4] postulated that it must act homogeneously. This view has recently received some experimental confirmation from the results of Erhard and Norrish[5], who followed the course of flash-initiated explosions of amyl nitrite, acetylene and oxygen by kinetic spectroscopy. Under these conditions the explosions have the character of homogeneous ignition analogous to detonation and the rate of temperature rise during the induction period is similar to that of the end gas of a spark ignition engine[6]. The inclusion of small partial pressures of lead tetraethyl in the charge increased the induction periods; this is equivalent to the effect of lead in engines, which is to inhibit the pre-flame reactions and to eliminate auto-ignition in the end gas. In these experiments the absorption spectrum of gaseous lead monoxide appeared strongly during the induction periods of one to two milliseconds duration, but there was no evidence for the separation of a solid phase. These experiments were later extended to *n*-heptane and *iso*-octane fuels, in place of acetylene[7], with similar results. Furthermore, it is now known that the maximum end gas temperatures in high compression ratio engines recorded by Livengood, Taylor and Wu[8] are too high to allow of the existence of colloidal lead oxide.

This communication describes in outline results arising from the application of the flash spectroscopic method to a study of the behaviour of some other compounds during explosions of mixtures of amyl nitrite, *n*-heptane and oxygen. The effect of these substances with respect to anti-knock action, smoke formation, effect on induction period (that is, pre-flame reaction) and the emission of light, is indicated by positive and negative signs in the table, which relates to partial pressures of the additives of up to 0·2 mm. A typical charge composition was 3 mm. of amyl nitrite, 2 mm. of *n*-heptane with 40 mm. of oxygen.

Table 1

	Anti-Knock	Smoke	Induction-period	Emission
$TeMe_2$	+	−	+	−
I_2	+	−	+	−
$PbEt_4$	+	−	+	−
$SiMe_4$	−	−	−	−
$SnEt_4$	−	+	−	−
AK-33X	+	+	+	+
$Fe(CO)_5$	+	+	−	+
Ferrocene	+	+	−	+
Hg vapour	−	−	−	−
Hg(iso-propyl)$_2$	−	−	−	−

With the tin and transition metal additives, smokes formed during the induction periods, characterized by a continuous scattering over the entire continuum. *AK–33X*[9] (methyl cyclopentadienyl manganese tricarbonyl) under special conditions also acts as a pro-knock by reducing the induction periods. The first three compounds listed in Table 1 all increased the induction periods without smoke formation. Tin tetraethyl gave rise to smoke formation but had no observable effect on the character of the ignition. The formation of colloidal solids has no effect on the auto-ignition delay and there is no correlation with anti-knock action.

A surprising feature of the experiments was that neither ferrocene nor iron pentacarbonyl affected the duration of the induction periods, under a wide variety of fuel compositions and flash energies, in spite of the fact that they are anti-knocks[10,11]. Smokes formed early in the induction periods, probably of colloidal ferric oxide. It is therefore concluded that the iron compounds and colloidal solids, formed during their combustion, do not delay auto-ignition by pre-flame end gas reactions. Since the essential function of any anti-knock is to eliminate

or to moderate auto-ignition in the end gases, the iron compounds must achieve this result by affecting the burning or burnt gases, at a temperature where the iron can act homogeneously. It follows that there are at least two quite different mechanisms of anti-knock.

From stoichiometric or oxygen-rich explosions containing manganese and iron additives, emission of the oxide spectra occurs with extraordinary brilliance; the light from a single explosion could be photographed after dispersion through a Hilger medium quartz spectrograph with a 0·02 mm. slit aperture. It is tentatively suggested that this intense emission of light is the cause of the second anti-knock effect. It could be of importance in an engine by affecting the temperature of the burning gas by radiative cooling or by removal of high potential chemical energy from initiating or propagating centres by electronic excitation of oxide molecules at points in the end gas where preignition is about to occur.

AK-33*X* showed features characteristic of both mechanisms, changing the duration of the induction periods, probably by homogeneous reactions in the end gas (the vapour pressure of MnO is intermediate between FeO and PbO), and also giving the intense light emission at the instant of ignition. A detailed account of these results is being prepared for publication.

A. B. Callear
R. G. W. Norrish
Department of Physical Chemistry,
University of Cambridge.
Nov. 2.

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Influence of Platinum in Mercury on the Mechanism of Electrode Reactions at the Mercury Electrode

Mercury electrodes used in electrochemistry are often prepared by plating mercury on solid electrodes. The formation of amalgams in these conditions has been in general disregarded. We have already shown[1] that when gold or gold-plated electrodes are covered with mercury, there are electrode reactions different from those on pure mercury, owing to formation of intermetallic compounds.

Comparative experiments were carried out using our hanging mercury drop electrode[2] and a platinum sphere of identical diameter, covered electrolytically with mercury[3]. Both electrodes, immersed in the same solution, were polarized, either cyclically or, after a concentrating electrolysis, an anodic oxidation curve was recorded.

Aqueous solutions of salts of thallium, lead, tin, antimony, cadmium and zinc were investigated. In certain cases (zinc, antimony and tin) a significant difference was observed for anodic oxidation on mercury electrode and on mercury-plated platinum. For 10^{-4} *N* zinc and cadmium solutions in 0·1 *N* potassium chloride cyclic voltammetric curves are shown in Fig. 1. The upper curve was obtained with a mercury-plated platinum electrode, the lower one with a pure mercury electrode. Fig 2. shows the recorded oxidation curves for a mercury-plated platinum electrode (upper curve) and for a mercury electrode (lower curve) when 10^{-6} *M* solutions of the same ions (containing traces of lead) were concentrated by 3 min. electrolysis.

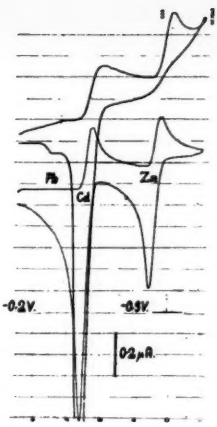

Fig. 1

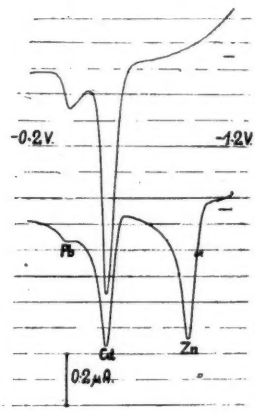

Fig. 2

It is evident that the behaviour of cadmium is similar at both electrodes, but differences are observed with zinc.

Cadmium is reversibly oxidized and reduced at the same potential; but for zinc, oxidation is completely inhibited, although zinc ions are reduced without any difficulty on both electrodes in a similar manner.

These differences can be explained if we assume the formation of platinum amalgam. Zinc, in this electrode, forms with platinum a stable intermetallic compound, which can be oxidized at more positive potentials than the mercury oxidation potential.

The behaviour of antimony and tin is analogous to zinc. An interesting conclusion of practical importance follows from Fig. 2. The separation of cadmium and traces of lead is much more pronounced on the upper curve. This seems to be due to a rather thin mercury film on the electrode, and hence it takes

a shorter time to oxidize the metal from the total bulk of amalgam.

Our experiments show that, when the dissolution of platinum and formation of intermetallic compounds in mercury are neglected, the interpretation of electrode processes may be erroneous.

Wiktor Kemula
Zenon Kublik
Zbigniew Galus

Institute of Physical Chemistry,
Polish Academy of Science,
Warsaw.

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Isomerization to the Tropylium Ion Induced by Electron Impact and its Significance

Ionization by electron impact of toluene[1,2] and some other compounds containing the benzyl group[3] leads to the formation of tropylium ions, as Meyerson and Rylander have shown by isotopic labelling[1] and comparison of the energy data as well as of the mass spectra[2] of toluene and *cyclo*heptatriene. The discovery of this rearrangement is of importance for the verification of basic conceptions on factors determining ion fragmentation (cf. ref. 4). In this connexion we should like to direct attention to the mass spectrum of *spiro*-(2,4)-*cyclo*heptadiene-(1,3).

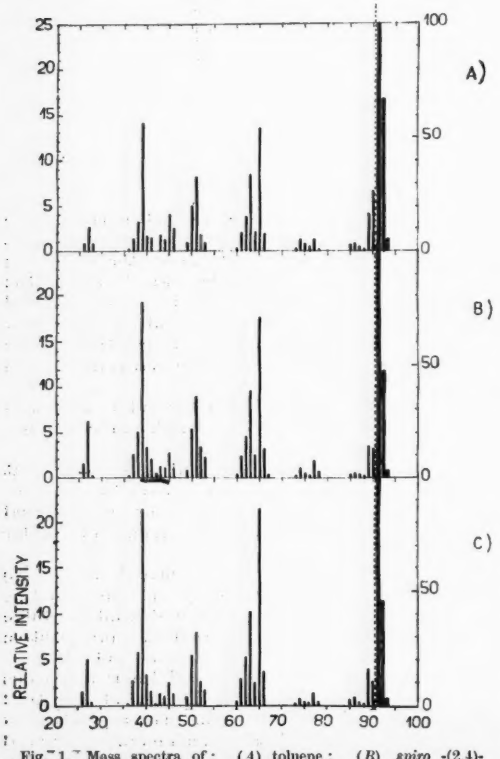

Fig. 1. Mass spectra of: (*A*) toluene; (*B*) *spiro*-(2,4)-*cyclo*heptadiene-(1,3); and (*C*) *cyclo*heptatriene (the sensitivity up to mass $m/e = 90$ is fourfold); Nier type ion source

The mass spectra of toluene, *cyclo*heptatriene and *spiro*-(2,4)-*cyclo*heptadiene-(1,3), shown schematically in Fig. 1, are very similar to each other; this seems especially remarkable for the second and third compounds, since the third has quite different chemical and physical properties[5] from the second. Within the limits of experimental error, the mass spectra of all three compounds are identically influenced, using the same Nier-type ion source, by changes of extracting electric field and by changes of electron focusing magnetic field. The effect of the energy of ionizing electrons upon the relative abundance of various ion species in the range 15–10 eV. studied is also very similar for all three compounds.

These results indicate that: (1) the electron impact ionization of *spiro*-(2,4)-*cyclo*heptadiene-(1,3) leads also to rearrangement of the carbon skeleton to a seven-numbered ring; (2) the predominating quantity of fragment ions is formed not from direct fragmentation of ionized molecules, but from sufficiently excited ions formed by the rearrangement; and (3) the ions with seven-numbered ring from *spiro*-(2,4)-*cyclo*heptadiene-(1,3) behave in this fragmentation either very similarly or even the same as the ions from *cyclo*heptatriene.

Since the relative abundance of various ion species arising from the fragmentation of rearranged parent ions is in these cases nearly the same, the redistribution of energy in this parent ion is essentially accomplished before fragmentation; this supports one of the basic conceptions of the quasi-equilibrium theory of ion fragmentation[6].

I thank Prof. D. N. Kursanov of Moscow, for the gift of *cyclo*heptatriene.

V. Hanuš

Institute of Physical Chemistry,
Czechoslovak Academy of Sciences,
Máchova 7,
Prague 12.
July 22.

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Separation of the *Meta*- and *Para*-Isomers of the Xylenes, Cresols and Toluidines by Gas Solid Chromatography

Attempts to improve resolution in gas chromatography have developed along two lines; first by the improvement of the efficiency of the column[1,2], and secondly by the use of more selective stationary phases[3,4]. These two methods are not mutually exclusive, and it is probable that the technique used in any particular case will depend upon the analysis required and the apparatus available. This note is concerned with one aspect of the second method, namely the use of solid absorbents to obtain increased separation factors[5].

White[5] has shown that a good separation of aliphatic from aromatic hydrocarbons could be obtained using a montmorillonite in which the naturally occurring inorganic ions had been replaced

by dimethyldioctadecyl ammonium ions. During an investigation into the use of the above organo-clay derivative (supplied by F. W. Berk and Co. Ltd., London; trade name *B*34) as a possible stationary phase for the analysis of crude benzoles by gas chromatography, the separation of *meta*- and *para*-xylene was readily achieved.

Table 1 shows the relative retention volumes for the three methyl benzenes measured on columns containing different samples of *B*34. These values have been expressed relative to the retention volume of *para*-xylene and in all cases the retention volume has been corrected for the dead space of the column, and measured to that point where the tangent to the point of inflection on the trailing edge of the elution curve intersects the base-line.

TABLE 1

Component	Relative Retention Volumes at 80°C. *B*34 (*a*)	*B*34 (*b*)
p-xylene	1·00	1·00
o-xylene	1·28	1·33
m-xylene	1·51	1·43

Fig. 1 is a chromatogram which was obtained from a column 90 cm. long × 0·6 cm. int. dia. packed with 10 gm. of 'Celite' (60–80 *B.S.* mesh), as diluent to 1·5 gm. of B34(*a*). This column was not very efficient but in the absence of *o*-xylene a complete separation could be obtained between the meta and para isomers.

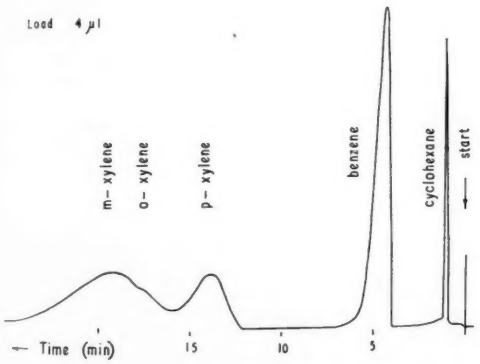

Fig. 1

Further work has shown that the isomers of the cresols and toluidines could also be separated, and the relative retention volumes on the most active clay are given below. In all cases the measurement was to the intersection of the tangent to the trailing edge and the base-line.

It should be noted that the asymmetry of the elution peaks shown in Fig. 1 was even more marked with the phenols and bases. This, however, could probably be reduced by the use of smaller samples, since in most cases the distribution isotherm becomes linear over smaller concentration ranges. This factor is of great importance when considered from the point of view of the more sensitive detectors now available, and it is possible that symmetrical peaks could be obtained from many adsorbents by using a very small charge.

TABLE 2

Component	Relative Retention Volumes at 200°C. *B*34 (*a*)
phenol	1·00
p-cresol	1·04
o-cresol	0·84
m-cresol	1·40
aniline	1·00
p-toluidine	1·03
o-toluidine	1·24
m-toluidine	1·60

We wish to thank the Gas Council for permission to publish this note.

M. A. HUGHES
D. WHITE
A. L. ROBERTS

Gas Research Department,
Houldsworth School of Applied Science,
University of Leeds.
Aug. 12.

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BIOCHEMISTRY

Fluorescent Schiff-Type Reagents for Cytochemical Detection of Polyaldehyde Moieties in Sections and Smears

THE standard Schiff reagent (basic fuchsin plus sulphurous acid) has been used widely in cytochemistry to localize such aldehyde moieties as deoxyribonucleic acid by the Feulgen reaction and 1, 2 glycols (polysaccharides) by the periodic acid-Schiff reaction. Work in this laboratory designed to provide other reliable aldehyde-specific reagents (Schiff-type reagents) has been completed[1,2].

Approximately 30 different colorimetric reagents are now available and may be judiciously combined with other reagents to provide polychromatic staining having chemical significance. These reagents are as selective for cyto-chemical purposes as the standard Schiff reagent, although most of them differ from Schiff's reagent in that they are coloured solutions.

Fortunately, some Schiff-type reagents are also fluorescent and structures stained by them in the Feulgen and periodic acid reactions give off brilliant fluorescence in the fluorescent microscope. The colours seen under these conditions depend on the reagent and the structures stained. Generally, brilliant yellow, yellow-green, orange, red, and brown colours are produced. Cytological detail with a given dye-reagent is usually clearer in the fluorescent microscope than in the ordinary light microscope. The increased sensitivity of the fluorescent technique has been pointed out by Ornstein *et al.*[3] in connexion with their studies of kidney slices using acriflavine-Schiff reagent in the periodic acid-Schiff reaction.

A list of fluorescent Schiff-type reagents is shown in Table 1. Physiological interpretation of fluorescence seen in aldehyde-stained preparations is facilitated with these reagents. All structures which fluoresce do so because of the presence of aldehydes that are chemically combined with the fluorochrome reagent. This fluorescence (secondary) is easily distinguished from any primary (auto) fluorescence

Table 1. Fluorescent Schiff-Type Reagents. Dye Solutions prepared and used in Feulgen and Periodic acid-Schiff Reactions as described in Text. Tissues include Mouse Intestine, Thyroid, Trachea, Ehrlich-Lettre Ascites Tumour and Human Liver

Reagent	Colour Index No. of dye	Colour of dye Solution	Fluorescence colour in aldehyde-stained tissues
Acridine Y-SO_2	46025	Yellow	Yellow-nuclei, thyroid colloid; yellow-orange-cartilage matrix; orange-intestinal goblet cells and Brunner's glands
Acriflavine-SO_2	46000	Yellow	Yellow-nuclei; orange-thyroid colloid, goblet cells; orange-brown-cartilage
Coriphosphine O-SO_2	46020	Yellow	Orange-nuclei, goblet cells, Brunner's glands
Flavophosphine N-SO_2	46065	Yellow	Yellow-nuclei; orange-goblet cells, Brunner's glands
Neutral Red-SO_2	50040	Red	Brown-nuclei, goblet cells, Brunner's glands
Phenosafranin-SO_2	50200	Red	Red-nuclei
Phosphine GN-SO_2	46045	Yellow	Orange-nuclei; brown-goblet cells
Rhodamine 3GO-SO_2	45210	Red	Orange-nuclei; goblet cells, Brunner's glands
Safranin O-SO_2	50240	Red	Brown-goblet cells

present in unstained material by use of suitable control slides. The reagents are prepared by making 0·25–0·50 per cent aqueous dye solutions (Feulgen) or 0·1 per cent solutions (periodic acid-Schiff), and then saturating the solutions with sulphur dioxide gas. Alternatively, this gas may be replaced by a few drops of thionyl chloride in 40 ml. of dye solution. Additional filtering may be necessary, but the solutions still retain aldehyde reactivity as long as sulphur dioxide is present. The solutions should be used in screw-capped Coplin jars or similar containers to reduce the loss of sulphur dioxide. In addition, when the solutions are not being used, it is advisable to store them in a refrigerator. Additional sulphur dioxide or thionyl chloride may be added as needed.

Smears or sections of tissue are treated and stained for polysaccharides (periodic acid-Schiff technique) in the usual manner[4]. The procedure for staining nuclei (deoxyribonucleic acid) with a fluorescent Schiff-type reagent may be carried out using 1 *N* hydrochloric acid at 60°C. or 6 *N* hydrochloric acid at room temperature. We normally use the latter procedure because it does not require a water-bath. Acid hydrolysis is carried out for 8 min. (6 *N* hydrochloric acid) or 15 min. (1 *N* hydrochloric acid) for formalin-fixed cells. The optimal hydrolysis time may need to be varied slightly for cells fixed in other fluids. Staining time in fluorescent Schiff-type reagents for the Feulgen technique is 20–45 min.; we use the longer time to assure complete reactivity.

Results obtained with a few tissues stained with these reagents are shown in Table 1. The colours produced are usually brilliant, especially in the case of the orange fluorescence seen in many periodic acid-Schiff structures using acridine reagents. Flavophosphine N-Schiff proved to be a particularly favourable reagent.

The Feulgen and periodic acid-Schiff reactions may be combined using contrasting dyes as Schiff-type reagents. Best results are obtained if the Feulgen reaction is carried out before the periodic acid-Schiff reaction. Brilliant colour combinations may be observed in many tissues using ordinary microscopy. When one of the dye-reagents is fluorescent, the stained structure (periodic acid-Schiff or Feulgen positive) stands out in striking contrast to the non-fluorescent dyed material in the fluorescent microscope. We are currently studying the use of multiple aldehyde stains where more than one reagent is fluorescent. Studies are also in progress using these fluorescent reagents to detect low concentrations of deoxyribonucleic acid in biological material and to analyse different polyaldehyde moieties in tissues.

The fluorescent dye, acridine orange, has been advocated for use in exfoliative cytology[5,6]. The advantages of acridine orange over the conventional Papanicolaou stain are also found in many of the reagents listed here. In addition, these new reagents have the advantage of providing greater cytochemical specificity than acridine orange, stained sections or smears may be viewed with fluorescent light or conventional transmitted light, and a greater variety of important cell compounds can be studied during normal and pathological processes. Studies are in progress to determine the feasibility of using some of these new reagents in a rapid cytochemical, fluorescent technique for detection of cancer cells in smears, especially for mass screening of cervical smears.

We wish to thank Dr. George E. Miller and Mr. Bill Reynolds for making available fluorescent microscope equipment, and Mr. F. F. Jacobs of Nova Chemical Corporation for samples of flavophosphine N and rhodamine 3GO. Our work is supported by Grant *C*-3420 (*C*1) from the National Institutes of Health, Bethesda, and aided in part by contract number *AT* (40–1) 2432 from the U.S. Atomic Energy Commission.

Frederick H. Kasten
Vivian Burton
Peggy Glover

Department of Biology,
Agricultural and Mechanical College of Texas,
College Station, Texas.
Aug. 31.

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Crystalline Cytochrome b_5

Cytochrome *c* and b_5 are the only cytochromes isolated from animal tissues in purified soluble forms which are reducible by soluble flavoprotein. Further studies on the enzymatic and chemical properties of cytochrome b_5 are badly needed.

Cytochrome b_5 can be obtained in good yield from pig liver, where it constitutes about 0·05 per cent of the total protein[1,2]. Pig liver particles obtained by acid precipitation of phosphate homogenates were extracted successively with lipase (10 mgm./gm. of protein, 1 hr. at 37° C.), and ethanol (10 per cent, 10 min. at 40° C.). The extract was fractionated with ammonium sulphate between 70 and 95 per cent saturation, adsorbed on '*DEAE*'-cellulose at *p*H 6 and eluted with *M*/4 phosphate buffer, *p*H 7·4. The cytochrome, then practically free of hæmoglobin, was twice purified by chromatography in hydroxylapatite, as previously described[1]. Purified cytochrome b_5 was concentrated *in vacuo*, adjusted at *p*H 6 and ammonium sulphate crystals added until turbidity developed. Large crystals appeared on standing for two weeks at 0° C.

The red hexagonal crystals were harvested by centrifugation and dissolved in water. Fig. 1 shows the spectra of oxidized and reduced cytochrome b_5 as obtained in a Carry recording spectrophotometer, model 14. The reduced cytochrome was prepared by

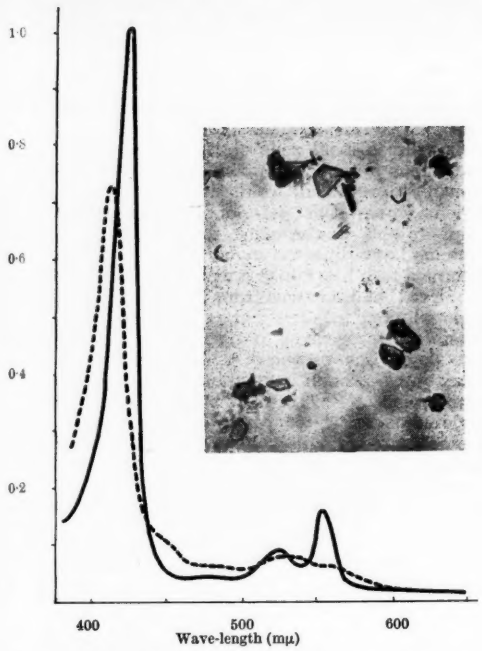

Fig. 1. Crystalline cytochrome b_5 from pig liver (× *c.* 130), and the spectra of the crystalline material. — — — — —, Oxidized form; ————, reduced form

treating the cytochrome with traces of purified reduced diphosphopyridine nucleotide-cytochrome b_5 reductase and reduced diphosphopyridine nucleotide. The preparation is now being studied further.

This work was supported by a grant from the Rockefeller Foundation to one of us (I. R.).

ISAIAS RAW
WALTER COLLI

Department of Biochemistry,
Faculty of Medicine,
University of Sao Paulo, Brazil.
Aug. 11.

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Regeneration of Protein from Insoluble Protein-Tannin Compounds

THE aims of the present studies were: (1) application of tannin to precipitation of different proteins; (2) removal of tannin from the insoluble protein-tannin compounds by the use of caffeine; (3) examination of some physico-chemical and biological properties of proteins after the regeneration process. The following proteins have been examined: gelatine, hæmoglobin, lysozyme, aldolase from rabbit muscle, potato proteins and proteins of normal biological human fluids.

It has been shown that not only anionic but also isoelectric proteins react with tannin in a reversible reaction according to the equation[1]:

$$\text{protein} + \text{tannin} \rightleftharpoons \text{protein-tannin} \quad (1)$$

Equilibrium point of the reaction was found to depend on *p*H as well as on the ratio of weight of the reactants. The protein-tannin precipitate is practically insoluble in water so it can be washed without loss from free tannin and non-protein components as well.

For the recovery of protein, the protein-tannin compounds are made to dissociate by decreasing tannin concentration. Caffeine has been applied to the removal of tannin from the reaction mixture, both in the presence or in absence of protein (equations 2 and 3).

$$\text{caffeine} + \text{tannin} \rightleftharpoons \text{tannin-caffeine} \quad (2)$$

$$\text{caffeine} + \text{protein-tannin} \rightleftharpoons \text{protein} + \text{caffeine-tannin} \quad (3)$$

It has been shown that both the reactions are reversible and the final state of the system depends on *p*H and on the molar ratio of caffeine to tannin. It has been shown that the protein can be recovered from the protein-tannin compounds with 90 per cent yield.

These observations have been applied to the concentration of the proteins of human biological fluids of low protein content (0·001–0·2 per cent) and those of salt extract of potatoes. The proteins were precipitated from the solutions examined at *p*H 4·7 by adding at first 40 mgm. of tannin to each 100 ml. of the solution and then an amount of tannin equal to total protein content of given volume of the solution. After the protein-tannin precipitate had been centrifuged and washed, an amount of caffeine twice as great as that of protein, was added. The precipitate was stirred with the caffeine and centrifuged. The supernatant was found to contain 2–7 per cent of the protein, about 1 per cent of caffeine and negligible amount of tannin. In that way 10–1000 times concentration of protein of solutions examined was obtained.

Some properties of regenerated proteins have been examined. Table 1 shows results obtained at electrophoretic separation of concentrated proteins from normal cerebrospinal fluid[1], urine[2], amniotic fluid[3], aqueous humor, diluted serum (control) and salt extract of potatoes[4].

Table 1. ELECTROPHORETIC PROTEIN FRACTIONS OF THE BIOLOGICAL FLUIDS AND OF POTATO EXTRACT AFTER CONCENTRATION BY TANNIN AND CAFFEINE

Fluid	Total protein in gm./100 ml. initially	Total protein in gm./100 ml. after concentration	Paper electrophoresis Relative per cent: Pre-alb.	Albumin	Globulins α_1	Globulins α_2	Globulins β	Globulins γ
Cerebrospinal fluid	0·02	1·9	4·7	55·4	4·8	7·9	15·4	12·4
Urine*	0·003	2·0	—	31·9	10·5	17·4	25·3	14·8
Aqueous humor	0·05	2·1	—	66·0	8·5		11·6	13·7
Amniotic fluid	0·18	6·7	—	66·7	3·2	8·2	9·6	12·3
Serum undiluted	6·8	—	—	61·5	4·3	7·9	9·8	16·5
Serum diluted with saline	0·006	4·1	—	62·3	4·0	7·8	10·1	15·8
Potato extract	0·17	1·7		30† (I)	40 (II)	20 (III)	10 (IV)	

* The determinations of proteins of normal urine were carried out after uromucoid had been eliminated according to Tamm and Horsfall (ref. 8). Quantitative determination of protein fractions according to Mejbaum-Katzenellenbogen *et al.* (ref. 7).
† The numbers in parentheses indicate the sequence of protein fractions towards anode (ref. 4).

Results obtained for fluids examined are strikingly similar to those found by other methods. It should be pointed out that proteins soluble in 0·2 *M* sulphosalicylic acid (acid glyco-proteins) can also be precipitated by tannin.

The regenerated proteins from serum retained specific, and those from potatoes non-specific, ability of agglutinating red cells. In that way Dobryszycka[5] found isohæmagglutinins in normal urine.

Two enzymes examined (aldolase and plant acid phosphatase) were found to retain enzymatic activity after the regeneration procedure. Specific activity of

the rabbit muscle aldolase was unaltered; but that of acid phosphatase was twice as high as in the crude salt extract from potatoes.

Moreover it has been demonstrated that the electrophoretic mobility of proteins (paper electrophoresis), solubility in water and in salt solutions, colour and nitrogen content remain unaltered after the regeneration procedure.

A more detailed report of these problems will be given elsewhere[4,6].

W. Mejbaum-Katzenellenbogen
W. Dobryszycka
J. Boguslawska-Jaworska
B. Morawiecka
Department of Biochemistry,
Medical School in Wroclaw,
Poland.
Nov. 9.

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Separation of Fast-Moving γ-Globulins by Starch-Gel Electrophoresis

One-dimensional electrophoresis in starch gel[1] performed in a discontinuous system of buffers[2] has shown several new protein components in the region between the slow-α_2 globulin (S-α_2) and transferrin (β-1-globulin). During the investigations of the origin of these new bands it became apparent that at least two belong to the 'fast moving' γ-globulins. The term refers to that portion of γ-globulins which are found by filter paper electrophoresis (sodium barbital-sodium acetate-hydrochloric acid buffer; ionic strength 0·1μ in the β-globulin region.

Using commercially prepared γ-globulin (Lederle *C*-496) as an antigen, potent antisera were prepared in rabbits. The distribution of γ-globulins was studied with the aid of starch-gel immunoelectrophoresis[3,4]. Fig. 1 shows the results obtained when a 2·5 per cent solution of the antigen and of normal human serum were subjected to starch-gel immunoelectrophoresis in the borate buffer and the discontinuous system of buffers. A 'forward' shift of the γ-globulins in the latter system is shown on Fig. 1*b*.

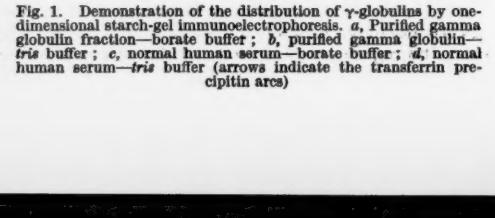

Fig. 1. Demonstration of the distribution of γ-globulins by one-dimensional starch-gel immunoelectrophoresis. *a*, Purified gamma globulin fraction—borate buffer; *b*, purified gamma globulin—*tris* buffer; *c*, normal human serum—borate buffer; *d*, normal human serum—*tris* buffer (arrows indicate the transferrin precipitin arcs)

Identical change in the position of the γ-globulins is shown on Fig. 1*d* for a normal human serum subjected to the same immunoelectrophoretic conditions. Since the antiserum used also contained antibodies against the β-1-globulin (transferrin), it was possible to locate the fast-moving γ-globulins under the precipitin arc belonging to this antigen.

Two-dimensional zone electrophoresis[5] in the discontinuous system of buffers[4] conducted on normal human sera revealed two distinct protein zones in the region where the β-1-globulin (transferrin) and β-lipoproteins are usually found. Since the two proteins have different mobilities in starch gel, they assume a fork-like appearance. The faster of the two is 'curved' and emerges from the γ-globulins into the β-globulin region. The shape of this zone points to the possible heterogeneous nature of this protein entity. The slower one, on the other hand, is migrating as a 'horizontal' protein zone thus indicating its relative homogeneity. Both of them belong to the fast-moving γ-globulins (cf. filter paper electrophoresis). Their separation cannot be achieved in the routinely used borate buffer. Fig. 2*a* and *b*, show typical distributions of the above-described proteins in a newly born and a four-months-old infant respectively. The latter

Fig. 2. Two-dimensional zone electrophoresis on γ- and β-globulins. *a*, Newly born; *b*, infant 4 months old

pattern is also typical of a not too frequent variant found in adults. The proteins described were invariably found in the sera of 50 normal adults and 30 normal infants and children of various ages. However, the faster component (curved) was usually depleted with the rest of the γ-globulins in infants belonging to the 3–4 months age group. This finding is in accord with the physiological hypogammaglobulinæmia of Barret and Volwiler[6] and with the findings of Bridges *et al.*[7]. On the other hand, the 'horizontal' protein component was found unchanged. When sera of 25 nephrotic children were screened, nearly complete depletion of the γ-globulins was found except for the two proteins described. However, in some of the very severe cases, the faster component was also absent. Increased amounts of this faster (curved) component were found in some cases of nephritis and cirrhosis. Recently Heremans, Heremans and Schultze have isolated and characterized a protein known as β_{2A}-globulin[8,9], the quantity of which was found to be increased in cirrhosis. A sample of this protein was obtained through the courtesy of Dr. H. E. Schultze, Behringwerke, Marburg, Germany, and tested for its possible relationship to either of the proteins described herein by us. To 0·12 ml. of a normal human serum was added 0·8 ml. of a 2 per cent solution of the β_{2A}-globulin. The control contained the same amount of serum and 0·8 ml. of physiological saline. Two-dimensional zone electrophoresis was then conducted in the same gel on the γ- and β-globulin regions of the mixture and the control. The amount

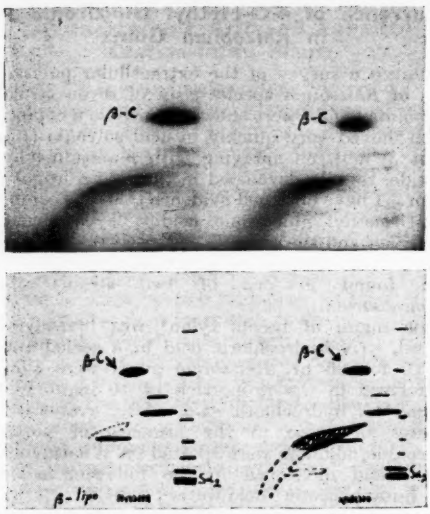

Fig. 3. Identification of β_{2A}-globulin by two-dimensional zone electrophoresis. Photograph: *a*, Normal serum; *b*, normal serum + β_{2A}-globulin. Graph drawn directly from photograph; *c*, Nephrotic serum; *d*, nephrotic serum + β_{2A}-globulin

of the faster component (curved) was found increased in the mixture (Fig. 3*b*). The slower component (horizontal) was unaffected. A similar experiment was conducted on a nephrotic serum in which all the γ-globulins were depleted except the two proteins described by us (Fig. 3c). It is apparent from Fig. 3*d* that the fast-moving component is identical with the β_{2A}-globulin. According to the immunoelectrophoretic determination of the β_{2A}-globulin (performed in Dr. Schultze's laboratory), the preparation contained also a small amount of γ-globulin and an α-2 globulin. Fig. 3*b* and especially 3*d* clearly show their presence, though the α-2 globulin was probably altered during the purification process since it now has the mobility of γ-globulin (both on filter paper and in gel).

Presence of γ-globulins in the β-globulin region was shown by Slater[10]. Our electrophoretic and immunoelectrophoretic experiments have shown two proteins in the β-globulin region belonging to the γ-globulins. One of these had a mobility identical to β_{2A}-globulin which according to Heremans *et al.*[8] bears an immunological relationship to γ-globulins. Immunoelectrophoretic identification of the slower (horizontal) component is in progress. We gratefully acknowledge the support of the Michigan Kidney Disease Foundation in this research.

M. D. Poulik
W. W. Zuelzer
R. Meyer

The Child Research Center of Michigan,
The Children's Hospital of Michigan,
and the Department of Pediatrics,
Wayne State University
College of Medicine,
Detroit, Michigan.

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Production of γ- and α-Globulins by the Isolated and Perfused Rat Spleen

The problem of sites of synthesis of γ-globulins and of their relative contribution to the total synthesis of these proteins in the normal animal has received little attention compared with that devoted to similar studies on the synthesis of antibody globulins. This problem becomes specially interesting if one considers the controversial views which have been put forward on the origin and nature of γ-globulins[1].

Incubation of tissue slices of normal rabbit lymph nodes, bone marrow and spleen, shows that these tissues incorporate amino-acids labelled with carbon-14 into the γ-globulin fraction of the plasma proteins[2]. Other authors, by perfusing the caudal moiety of the rat carcass with blood to which lysine labelled with carbon-14 was added, concluded that bone marrow was probably the most important site of production of γ-globulins[3].

This communication reports findings with the isolated perfused rat spleen. When this organ was perfused with heparinized blood deprived of white cells and platelets, and to which labelled lysine had beed added, significant incorporation of this amino-acid occurred into γ-globulin. Evidence is also presented indicating that the spleen synthesizes α-globulins.

After excision of lymph nodes, pancreas and fatty tissue surrounding the splenic artery and pedicle, the vessel was cannulated and venous outflow induced by section of the portal vein. The spleen was placed in a perfusion apparatus which allowed circulation of 40–60 ml. of oxygenated blood—at constant temperature and pressure—to which was added a tracer dose of the labelled amino-acid. Freshly drawn heparinized blood from groups of donor rats was deprived of its white cells and platelets, so as to avoid the production of vasoactive substances. The blood flow was controlled by measuring the drip rate at the portal end of the preparation. The experiment lasted 4½ hr. Conveniently spaced samples were withdrawn on which the hæmatocrit and the total plasma protein level were measured. After treating the plasma proteins to get rid of free labelled lysine the specific activity was measured by a $^{14}CO_2$ gas counting method[4]. When the experiment was over, enough plasma was taken to allow separation of the different plasma proteins.

Results are expressed in terms of percentage dose incorporated into total plasma proteins at different times. The values obtained in eight experiments are shown in Fig. 1. After a perfusion period of 4½ hr. their range is 1–3 per cent of the dose. The graph shows a lag period of approximately 30 min. which is then followed by a linear increment of radioactivity of the plasma proteins. This behaviour has been observed and discussed by other authors in studying plasma protein synthesis by isolated organs[5,6] and tissue slices[7,8].

That incorporation of the amino-acid is really into the protein molecule was shown more specifically by measuring the specific activity of $^{14}CO_2$ liberated by glutamic acid decarboxylase from an acid hydrolysate of the plasma proteins obtained in one experiment in which labelled ^{14}COOH-glutamic acid instead of labelled lysine was added. Consistent values were obtained for this same experiment by measuring the specific activity of $^{14}CO_2$ produced by combusting the plasma proteins.

Separation of the different plasma protein fractions was accomplished in three experiments by means of *DEAE* and *CM* cellulose column chromatography[9–11].

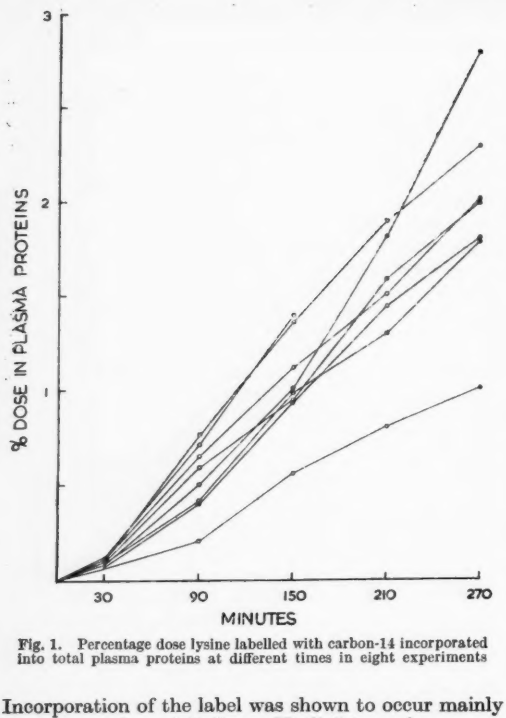

Fig. 1. Percentage dose lysine labelled with carbon-14 incorporated into total plasma proteins at different times in eight experiments

Incorporation of the label was shown to occur mainly into γ- and α-globulins. Negligible values were obtained for albumin; but results for β-globulin were inconclusive because of technical difficulties in obtaining an uncontaminated preparation. The highest specific activity was found for the slower γ-globulin as shown by paper electrophoresis.

These experiments show that the perfused isolated rat spleen synthesizes α- and γ-globulins; but calculation of the actual amount of proteins synthesized on the basis of plasma protein specific activities was not attempted because of lack of information about intracellular amino-acid specific activities[12].

The finding that spleen as well as liver synthesizes α-globulins suggests that the reticulo-endothelial system, in which liver and spleen are both rich, may play a part.

These experiments and others related to them will be published in full in the near future.

I would like to acknowledge Dr. A. H. Gordon's help and supervision in this work and Dr. S. Cohen's advice on chromatographic separations.

E. Espinosa*

National Institute for Medical Research,
Mill Hill,
London, N.W.7.

* Rockefeller Foundation Fellow.

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Occurrence of 4-O-Methyl Glucuronic Acid in *Rhizobium* Gums

During a survey of the extracellular polysaccharides of *Rhizobium* species[1], six of seven strains of *Rhizobium trifolii* were shown to include a component which moved very quickly in acid solvents ($R_{glucose}$ about 3) and, on spraying with *p*-anisidine hydrochloride, rapidly developed in the cold a bright pink colour. I have obtained evidence that this compound is 4-O-methyl glucuronic acid. Seven strains of *R. meliloti* and the one of *R. phaseoli* that was tested lacked this component which has however since been found in one of two strains of *R. leguminosarum*.

One mgm. of beech xylan[2] was hydrolysed in 0·2 ml. 1*N* hydrochloric acid in a sealed tube at 100°C. for 20 hr. *Rhizobium* gums were similarly hydrolysed in the proportion of 10 mgm. gum in 0·5 ml. 1*N* hydrochloric acid. After evaporation to dryness *in vacuo* in the presence of potassium hydroxide, aliquots were spotted on Whatman No. 1 paper, and developed in the following solvents: (*a*) butanol:acetic acid:water, 6:1:2; (*b*) ethyl acetate:acetic acid:formic acid:water, 18:3:1:4; (*c*) phenol:water, 4:1; (*d*) propanol:water, 3:2; (*e*) butanol:pyridine:water; 10:3:3. In solvents (*a*) and (*b*) the beech xylan hydrolysates showed two spots. One of these corresponded to xylose, and the other, which moved with the same R_F as the fast-moving components in the gum hydrolysates, also developed its pink colour in the cold. Aspinall *et al.* state[2] that beech xylan is composed of xylose and 4-O-methyl glucuronic acid. Hough *et al*[3] found that the methylated uronic acids tested by them with *p*-anisidine hydrochloride rapidly produced red colours of high brilliance. In solvent (*c*) the unknown component of the gums ran with the same R_F as xylose and the beech xylan hydrolysate showed only a single spot at the xylose level. In alkaline solvents (*d*) and (*e*), the component was held at the starting point in both beech xylan and the gum hydrolysates. Chromatograms run in solvents (*a*) and (*b*) and sprayed with brom-cresol blue showed that the component had an acid reaction.

Rhizobium gum (100 mgm.) was hydrolysed in 10 mgm. lots and the hydrolysates run as a band in solvent (*a*). The fast-moving component was eluted from the paper chromatogram and found to give a positive carbazole reaction for uronic acids with a peak in the absorption curve at 530 mμ (Dische[4]). A similar curve was given by the beech xylan.

4-O-methyl glucuronic acid, a common constituent of hemicelluloses, has not to my knowledge been reported previously from a bacterial source.

My thanks are due to Dr. A. D. Brown of the Commonwealth Scientific and Industrial Organization Marine Laboratory, Sydney, for much helpful advice and for a sample of beech xylan originally obtained from Dr. G. O. Aspinall.

Beverley A. Humphrey

Microbiology Laboratory,
School of Agriculture,
University of Sydney.

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Conversion of Salicylic Acid to Gentisic Acid and o-Pyrocatechuic Acid, all Labelled with Carbon-14, in Plants

METHYL salicylate has been found to occur both in the free state[1] and as the aglycone of a primeveroside, gaultherin[2] in *Gaultheria procumbens* L. (Ericaceæ).

Although it has been shown that salicylic acid gives rise to gentisic (2, 5-dihydroxybenzoic) acid in animal tissues[3] and micro-organisms[4], little is known about its metabolism in plants. By means of paper chromatography, Griffiths[5] has shown recently that gentisic acid is widely distributed in higher plants. The fact that both salicylic and gentisic acids occur together in some species prompted us to study the relationship between these two acids.

We have found that when carboxyl-labelled salicylic acid-^{14}C is administered to plants, it is converted to gentisic and *o*-pyrocatechuic acids (possibly in the form of glycocides). The methods of administering the compound and extracting the plant material have already been described[6]. The ethanol extracts were acid hydrolysed, continuously extracted with ether, taken into 5 per cent sodium carbonate, then re-extracted with ether after acidification. The final ether extracts were evaporated to dryness at room temperature and the residue dissolved in 80 per cent ethanol and chromatographed on Whatman No. 1 filter paper using the organic layer of a mixture of (6:7:3) benzene:acetic acid:water for the first direction and (10:1:200) sodium formate: formic acid:water for the second. The chromatograms were autoradiographed and radioactive determinations were carried out by direct counting on the paper using a thin end window Geiger-Müller tube attached to a scaler.

Salicylic acid-^{14}C was also administered to leaves of 5-day-old wheat seedlings, mature leaves of *Rhododendron* sp. and of *Lotus arabicus*, and the material analysed in the same way. The results are shown in Table 1. No other acids apart from salicylic, gentisic and *o*-pyrocatechuic acids were found to be radioactive in any of these extracts.

Table 1. DISTRIBUTION OF RADIOACTIVITY IN PHENOLIC ACIDS OF LEAVES OF VARIOUS PLANTS FED WITH SALICYLIC ACID-^{14}C

Plant	Percent Radioactivity		
	Gentisic	*o*-Pyrocatechuic	Salicylic
Gaultheria procumbens	32·1	65·2	2·7
Rhododendron sp.	6·4	9·8	83·7
Lotus arabicus	14·1	14·0	71·9
Triticum vulgare v. *Thatcher*	26·8	4·0	69·2

Gentisic and *o*-pyrocatechuic acids were identified by the isolation of small amounts from the leaves of *Gaultheria procumbens*. They were located by their fluorescence in ultra-violet light and by colour reactions with diazotized *p*-nitroaniline, diazotized sulphanilic acid and 1 per cent ferric chloride. *p*-Pyrocatechuic acid was crystallized from benzene-ether and recrystallized from hot water. It decomposed at 204–206°C. (uncorrected). Mixing with an authentic sample of 2, 3-dihydroxybenzoic acid did not lower the melting point. Infra-red spectra of the isolated acid and authentic *o*-pyrocatechuic acid were identical. Gentisic acid was crystallized in the same way as *o*-pyrocatechuic acid; it melted at 201–202°C. (uncorrected).

By means of chromatography, *o*-pyrocatechuic acid was also found to occur in acid hydrolysates of ethanolic leaf extracts of *Rhododendron* sp., *Azalea* sp., *Erica carnea*, *Vinca rosea*, *V. minor* and *V. major* This acid has been reported previously to occur in *Populus balsamifera*[7] and as a glucoside in *Vinca minor*[8]. The identification of *o*-pyrocatechuic acid in five genera of the Ericaceæ suggests that it may be of widespread occurrence in this family.

We have found, by means of paper chromatography, that acid hydrolysates of 30 species analysed for phenolic acids contained gentisic acid in almost every case, whereas salicylic acid was confined to a few species. However, the demonstration that gentisic acid is readily synthesized from salicylic acid in four different species including a monocotyledon suggests that salicylic acid is a common metabolite of plants. It is an interesting fact that the wheat plant which contains none of these acids in a free or bound form is capable of converting salicylic to gentisic and *o*-pyrocatechuic acids.

While protocatechuic (3, 4-dihydroxybenzoic) acid has been shown to be formed from shikimic acid[9], the precursors of the ortho-hydroxybenzoic acids are not known. We have found that when carboxyl-labelled benzoic acid-^{14}C is administered to plants, salicylic, gentisic, *o*-pyrocatechuic and *p*-hydroxybenzoic acids are formed. This problem is under investigation.

We thank the National Research Council of Canada for financial support of this work. We wish to thank also the World University Service of Canada for the award of a scholarship to one of us (R.K.I.). Dr. Zacharius of the Zoology Department of McGill University kindly prepared the infra-red spectra.

RAGAI K. IBRAHIM
G. H. N. TOWERS

Botany Department,
McGill University,
Montreal 2, Canada.
Aug. 31.

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PHYSIOLOGY

Effect of Jet Aircraft Noise on Hearing

FOR a long time the hearing of personnel in the Services has been endangered by the noise of gunfire and its deafening effects are well known. Next to gunfire, the modern turbo-jet engine is probably the source of the most intense noise to which large numbers of men are being exposed at present. Various attempts have been made to detect any permanent deterioration in hearing resulting from jet noise but, until recently, no significant changes have been found. Whereas the less intense noise of piston-engined aircraft produces the typical loss of hearing acuity of acoustic trauma which appears first in the region of 4 kc./s., this form of defect has not been evident with exposure to jet noise.

Under existing conditions with jet aircraft, it is no longer the men who fly the aircraft who are subjected to the greatest noise but the attendant ground staff. Those in the worst situation are the men employed

on the flight deck of an aircraft carrier during aircraft launching operations, when many jet aircraft in succession are run at full power for catapulting from the ship. Both in Great Britain and the United States attention has been given to this problem, and Ward[1] has reported negative results following a comprehensive survey of the hearing of flight-deck personnel in the U.S. Navy. He concluded that gunfire was still the major cause of loss of hearing among these men. However, Ward found some evidence of *temporary* losses of hearing resulting from jet noise which were more uniform with frequency than the audiometric losses caused by gunfire and other impact noises.

For the American work an automatic method of audiometry was used to test ten men simultaneously. Late in 1957, the hearing of the flight-deck personnel of H.M.S's. *Ark Royal* and *Eagle* was examined by an individual method with a clinical pure-tone audiometer, and careful account was taken of each subject's noise experience. Those subjected to excessive gunfire or other occupational noises were excluded from the analysis, as were those with signs of pathological conditions affecting hearing. From each man's Service history and the operational history of the aircraft carriers concerned, his jet-noise exposure was assessed in terms of number of catapult take-offs. It was then possible to divide the men in three grades of noise-exposure (each comprising about fifty men).

The median hearing losses of the groups were compared with the hearing level of a comparable group of 74 young naval recruits at H.M.S. *Raleigh*, a shore training-establishment. Calibration of the audiometer at the National Physical Laboratory revealed the hearing of the recruits to be close to the British Standard normal threshold of hearing[2] at each octave from 250 c./s. to 8 kc./s. and demonstrated the applicability of the standard to work of this kind.

There had been no flying operations for more than three weeks prior to the hearing test of the men from the aircraft carriers, and hence most of the temporary depression of hearing by aircraft noise was considered to have subsided. The men were tested ashore and were usually examined within an hour of leaving the ships.

With these test conditions, it was found that the group with minimum exposure to aircraft noise had a slight loss of hearing of perceptive type amounting to about 5 db. throughout the frequency-range tested. The group with maximum exposure (averaging almost 2,500 catapult take-offs during 18 months) showed an additional loss of roughly 5 db. at 1 and 2 kc./s., where the difference between the hearing of this group and the one with minimum exposure was highly significant ($P<0{\cdot}01$).

The men with middle-grade exposure to noise (average 800 catapult take-offs) exhibited an intermediate degree of loss of hearing at mid-frequencies, but this was not significantly different from that of the least exposed group. Forty-one men exposed to aircraft noise who were excluded from the main analysis on account of having experienced more than a certain amount of gunfire were treated separately. The median hearing loss obtained here consisted of a mid-frequency loss together with a notch maximal at 6 kc./s.

It appears that the 5 db. hearing loss of those with least exposure to aircraft noise is general among ship-borne personnel, since a similar loss has been found in men from other types of ship including submarines. No doubt this effect originates in the noise to which crews are subjected for long periods without respite; but the uniformity of the loss as a function of frequency, found both in individuals and in the median loss of a group of men, is not the usual pattern obtained in losses induced by noise. That the effect is temporary has been established by testing men after a few days ashore, but any general recovery in the first hours has proved difficult to detect.

It could be argued that the total loss of hearing measured in those with greatest exposure only amounted to 10 db. and therefore is of little clinical significance. However, it should also be considered that the loss quoted is the *median* loss of a group, and therefore half the men have a greater loss. Furthermore, the frequencies involved are important for understanding speech; and the men tested had but little experience of the noisiest aircraft and had been exposed to aircraft noise over a period of about 18 months only. Thus it is apparent that all possible measures to protect hearing of the men at risk are required. A type of noise-excluding helmet was available to a large proportion of the men, but the helmets were by no means always correctly worn. It was confirmed that, within one of the grades of greater noise exposure, the helmets gave a protective effect from loss of hearing which was significant at 1 and 2 kc./s. ($P<0{\cdot}05$).

More recently, comparable effects have been determined by similar tests, but this time using a before- and after-exposure method, with the flight-deck men of the new aircraft carrier H.M.S. *Victorious*. In this case a higher proportion of noisier aircraft were flown and greater attention was paid to the wearing of protective helmets. The 5 db. ship-borne effect was again found, together with a significant additional mid-frequency loss in the group most exposed to aircraft noise. This amounted to a median loss of about 3 db. in 59 men who had experienced 500 catapult take-offs during eight months.

Hearing defects induced by noise extending from 500 c./s. to 3 kc./s., such as are attributed here to jet noise, are uncommon but can be accounted for by the unusual physical character of the noise modified by the frequency-selective properties of the ear protection. The noise of a turbo-jet engine at full power has a continuous spectrum, resembling modified random noise, and the energy is spread almost uniformly over a wide frequency-range. In conjunction with the intermittent exposure to this noise hazard (in which respect it differs markedly from that in most industrial situations), the uniform disposition of the high-intensity sound over a wide spectrum is thought to account for the measured effects on hearing being relatively slight.

A detailed report of the above investigation will be published elsewhere.

This communication is based on work performed for the Royal Naval Personnel Research Committee of the Medical Research Council; we are indebted to the commanding officer, officers and ratings of the ships concerned for their co-operation and to Dr. T. S. Littler, director of the Wernher Research Unit on Deafness, for advice and guidance.

R. R. A. Coles
Royal Navy.

J. J. Knight
Wernher Research Unit on Deafness,
Medical Research Council.
Kings College Hospital Medical School,
London, S.E.5

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Promoting Effect of Urea on the *in vitro* Passive Sensitization of Isolated Plain Muscles with Precipitating Antibody

It has been proved[1] that carbonic acid exerts an inhibitory effect on *in vitro* sensitization of isolated guinea pig plain muscles.

The following investigations provide evidence that urea has a promoting effect on passive *in vitro* sensitization of isolated tissues.

The technique used is as follows: strips of guinea pig intestine are immersed in a Tyrode solution containing a known amount of rabbit antiovalbumin antibody. When the antigen (ovalbumin) is added after a certain time allowed for contact, contraction of the muscle is observed. The intensity of the contraction is a function of the concentration of the antibody duration equal periods of contact. By comparing the amount of contraction with this produced by a standard solution of histamine, it is possible to make a rough evaluation of the intensity of the sensitization.

We have found that the addition of urea to the Tyrode solution containing the antibody enhances significantly the process of sensitization of the intestine. This effect is already evident with a concentration of 0·16 mol. of urea; but it is more striking when the urea concentration is raised to 0·8 mol.

A typical example of this enhancing effect of urea is illustrated in Fig. 1.

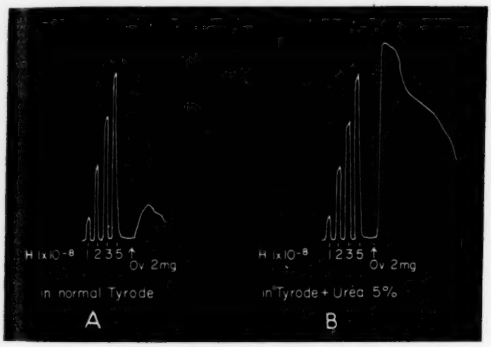

Fig. 1. Two adjacent strips of guinea pig ileum *A* and *B* sensitized passively *in vitro* with 5 μgm. N/ml. of rabbit antiovalbumin antibody. Time of incubation: 20 min. at 37° C. in Tyrode solution. *A*, control in Tyrode solution; *B*, Tyrode solution containing urea at a concentration of 0·8 mol.; *H*, addition of histamine dihydrochloride; *Ov*, addition of 2 mgm. of crystallized hen ovalbumin.

The promoting effect of urea on the sensitizing process is possible only when it is added in the presence of the antibody. Treatment of the tissue with urea, prior to or after sensitization, does not produce the same result, provided that the tissue has been sufficiently washed clear of the traces of urea. However, if the intestine has been sensitized in the presence of urea, subsequent washings do not affect the enhanced immunological response.

From these results, it can be deduced that urea affects the process of sensitization rather than the sensitivity of the intestine to histamine.

The relationship between the intensity of the anaphylactic response and the incubation time for the same antibody concentration in the standard conditions and in presence of urea is indicated in Fig. 2. Although the slopes of the sensitization curves vary with the antibody concentrations and although a wide range of variations has been observed with strips from various animals, the promoting effect of urea at the concentration of 0·8 mol. was always about four times.

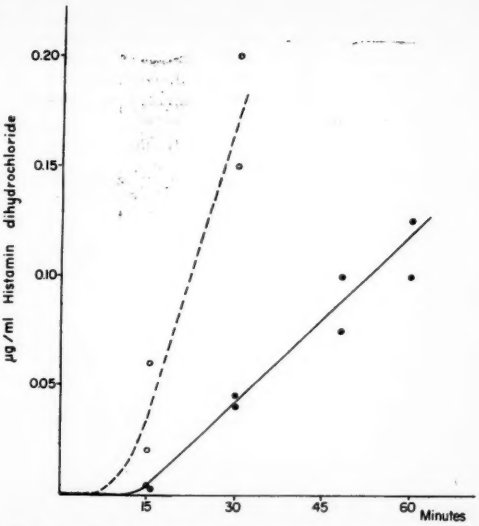

Fig. 2. Height of the anaphylactic contraction of strips of guinea pig ileum, taken from the same animal, sensitized passively *in vitro* with the same antibody concentration (16 μgm. N/ml.) and incubated during various times. ●, — Strips immersed in standard Tyrode solution; ○, — strips immersed in Tyrode solution containing 0·8 mol. of urea (5 per cent). Ordinate, height of anaphylactic contraction as expressed by corresponding histamine concentrations which produce identical contraction; abscissa, time of incubation (min.)

The nature of the phenomenon described is not yet clearly understood. It is possible that urea decreases the number of the hydrogen bonds between the antibody molecules and water, and so facilitates diffusion of the antibody through the cellular structures involved in the sensitization process.

R. Binaghi
B. N. Halpern
P. Liacopoulos
T. Neveu

Centre de Recherches Allergiques
de l'Association Claude Bernard
and Centre National
de la Recherche Scientifique,
Hôpital Broussais,
96 rue Didot,
Paris, 14.

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Reversal of Effects of 2-Substituted Thiadiazoles by Nicotinamide Analogues and Precursors

The 2-substituted thiadiazoles have been found to produce a variety of biological effects—the inhibition of growth of transplanted tumours and leukæmias in mice[1,2], the production of glossitis in man[3], and an increase in *de novo* synthesis of uric acid in man[3]. These effects can be prevented by nicotinamide which has led some observers to regard the thiadiazoles as 'nicotinamide antagonists'[4,5].

Since the chick embryo produces uric acid during development, it was used for the further investigation of the effects of the thiadiazoles on synthesis of uric

acid and the relationship of these compounds to nicotinamide, nicotinamide precursors and some nicotinamide analogues. The results of these studies, all employing 2-ethylamino-1, 3, 4-thiadiazole as a prototype compound, are summarized in Table 1.

Table 1. Reversal of 2-Ethylamino-1, 3, 4-Thiadiazole by Nicotinamide and Related Compounds

Compounds	Uric acid (mgm./egg ± SD*)†	DPN γ/embryo (mean of 3 or more specimens)
Control	11·5 ± 0·71	595
EA-TDA, 10 mgm.	24·7 ± 2·57	635
Nicotinamide, 1 mgm.	11·5 ± 1·14	673
Combination	14·7 ± 1·95	822
Control	12·4 ± 0·41	742
EA-TDA, 10 mg.	21·7 ± 1·96	672
Nicotinamide, 10 mgm.	13·4 ± 1·22	990
Combination	12·9 ± 0·28	958
Control	15·7	693
EA-TDA, 10 mgm.	25·7	
dl-Tryptophan, 5 mgm.	12·7	629
Combination	16·6	645
Control	9·6 ± 0·82	640
EA-TDA, 10 mgm.	23·8 ± 1·81	716
DPN, 10 mgm.	15·4	820
Combination	15·4 ± 2·61	661*
Control	15·2 ± 1·36	636
EA-TDA, 10 mgm.	31·8 ± 2·11	602
6AN, 0·07 mgm.	14·2 ± 0·97	285
Combination	13·3 ± 1·63	387
Control	11·4 ± 0·96	538
EA-TDA, 10 mgm.	22·4 ± 1·79	449
3AP, 1 mgm.	10·1 ± 0·45	107
Combination	14·3 ± 3·34	155

* Where S.D. is not given, the value given is the mean of only four determinations.
† Single specimen.
EA-TDA = 2-ethylamino-1, 3, 4-thiadiazole.
DPN = diphosphopyridine nucleotide.

In this system, as in man, nicotinamide blocks the uricogenic effect of 2-ethylamino-1, 3, 4-thiadiazole. Because of the known role of nicotinamide in diphosphopyridine nucleotide synthesis, the latter was measured in the total chick embryo in specimens chosen at random from each of the groups. (Analyses were performed by ultra-violet spectrophotometry at 340 mμ using yeast alcohol dehydrogenase.) 2-ethylamino-1, 3, 4-thiadiazole did not alter the diphosphopyridine nucleotide content of the embryo nor did nicotinamide in doses adequate to block the 1, 3, 4-thiadiazole effect. Larger doses of nicotinamide produced an increase in diphosphopyridine nucleotide which was not modified by the simultaneous administration of 2-ethylamino-1, 3, 4-thiadiazole.

In order to determine if the 1, 3, 4-thiadiazole effect were due to a block in nicotinamide synthesis (which could be reversed by supplying exogenous nicotinamide), the influence of tryptophan, a nicotinamide precursor, was studied. The table demonstrates that *dl*-tryptophan markedly modified the 1, 3, 4-thiadiazole effect. No changes in diphosphopyridine nucleotide content were seen at these doses of tryptophan.

Diphosphopyridine nucleotide at doses equal to the dose of 2-ethylamino-1, 3, 4-thiadiazole was also capable of blocking the 1, 3, 4-thiadiazole effect. A smaller dose of diphosphopyridine nucleotide failed to prevent the 1, 3, 4-thiadiazole effect. Regardless of the dose of diphosphopyridine nucleotide there was no significant increase in the diphosphopyridine nucleotide content of these embryos. It is likely, therefore, that the administered diphosphopyridine nucleotide was broken down and merely contributed enough nicotinamide (approximately 2·5 mgm./egg) to block the 1, 3, 4-thiadiazole effect.

6-Aminonicotinamide and 3-acetylpyridine are analogues of nicotinamide which have been shown to be incorporated into the diphosphopyridine nucleotide molecule by exchange with the nicotinamide moiety[6,7]. They have been found to produce specific developmental defects in the chick embryo and these effects are prevented by nicotinamide[8,9,10]. Following Burchenal and Oettgen's observation[11] that 6-aminonicotinamide could reverse the antileukæmic effect of 2-amino-thiadiazole in transplanted mouse leukæmia, the relationship of these compounds was explored in the chick embryo. In spite of their marked toxicity and known anti-nicotinamide properties, 6-aminonicotinamide and 3-acetylpyridine have both failed to produce an increase in uric acid production. Furthermore, both of these compounds, which markedly reduced diphosphopyridine nucleotide content, prevented the uricogenic effect of 2-ethylamino-1, 3, 4-thiadiazole, just as nicotinamide did (although lower doses of 6-aminonicotinamide were required). This reversal occurred along with a decrease in diphosphopyridine nucleotide content such as was seen with 6-aminonicotinamide 3-acetylpyridine alone. The characteristic and separate teratogenic effects of 6-aminonicotinamide and 3-acetylpyridine were not modified by the simultaneous administration of 2-ethylamino-1, 3, 4-thiadiazole.

This presents the unusual situation of a group of compounds (the 2-substituted thiadiazoles) the uricogenic effects of which are prevented by a metabolite (nicotinamide) or its precursor (tryptophan) and also by two corresponding antimetabolites (6-aminonicotinamide and 3-acetylpyridine). The specific teratogenic effects of these two antimetabolites are in turn prevented by nicotinamide.

These facts suggest that 'nicotinamide antagonists' may act by different mechanisms or at different metabolic loci and potent antagonists of one type (6-aminonicotinamide and 3-acetylpyridine) appear to function as metabolites in opposing the effect of a different type of 'antagonist' (the 2-substituted thiadiazoles). The interrelationships of nicotinamide and these antagonistic substances require further clarification.

This investigation was supported by research grants *CY*-3192 and *CY*-3215 from the National Cancer Institute of the National Institutes of Health, Public Health Service; and the American Cancer Society.

Irwin H. Krakoff
Corrine R. Lacon
David A. Karnofsky

Divisions of Clinical and Experimental Chemotherapy,
Sloan-Kettering Institute for Cancer Research,
Cornell University Medical College, New York.
Sept. 21.

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A Functional Interpretation of the Electron-Microscopic Structure of the Sensory Hairs in the Cristæ of the Elasmobranch *Raja clavata* in Terms of Directional Sensitivity

THE sensory cells in the vertebrate labyrinth are epithelial cells innervated by end-branches of bipolar neurons of the various first-order ganglia associated with the 8th cranial nerve. Physiologically, the response behaviour of these cells has been thoroughly analysed in the semi-circular canals and otolith organs of the labyrinth of the elasmobranch fish, *Raja clavata*[1-3] and of the frog[4].

An oscillographic single-unit analysis has shown that such a sensory cell may be in a state of continuous activity resulting in a continuous train of low-frequency impulses. This activity is modulated by an increase or decrease in impulse frequency, and this two-way modulation conveys unambiguous information about the strength and direction of the mechanical deformation of the hair processes of the sensory cell. In the ampullæ of the semicircular canals the hair processes are embedded in a jelly-like cupula terminalis, the movements of which, brought about by movements of the head in space, lead to the deformation or displacement of the sensory hairs in one or other direction.

It has so far been impossible to say when bending or shearing of the hair in one direction should lead to depolarization (increase in impulse frequency) or hyperpolarization (decrease in impulse frequency) in the sensory nerve.

It has been customary to attribute the basic activity purely metaphorically to a 'certain tension' that could be either relieved or aggravated by mechanical deformation in opposite directions[1]. It looked as if some part of the whole system ought to show a marked asymmetry, morphological or functional, and it occurred to us that the sensory hair process itself may be the seat of this asymmetry.

In 1956, one of us (J. W.) carried out an electron-microscopic study of the sensory epithelia in the semicircular canals of the guinea pig and found that the hair process of the sensory cell is a compound structure

Fig. 1. Copy of an electron-photomicrograph of a slightly oblique section through part of a compound hair process from a sensory cell in the crista of a semi-circular canal. *K*, kinocilium

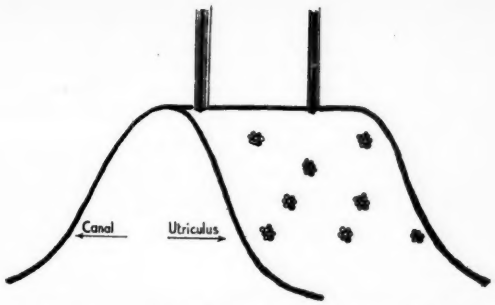

Fig. 2. Diagrammatic representation of the crista of the horizontal semi-circular canal, showing two compound hairs and several compound hair bases on the side of the crista facing the utriculus. The kinocilium is indicated in solid black. Note its spatial arrangement on the crista. Hairs and hair bases are magnified out of proportion to the size of the crista and their density is very much reduced. In a vertical canal the hair-bearing surface shown would face canalwards

consisting of a number of protoplasmatic filaments, one of which has the typical electron-microscopic structure of the kinocilium, namely, 9 peripheral, plus 2 central longitudinal fibrillae. It was tempting to assume, therefore, that the kinocilium, deprived of the freedom of active movement by being ensheathed in the cupula, might act as a 'motile structure in reverse' by responding to passive deformation with the initiation of an electric change (see also Gray and Pumphrey[5]).

We have now subjected the sense endings of the labyrinth of *Raja clavata* to an electron-microscopic scrutiny and we found that here, too, the sensory process is a compound structure with one kinocilium per sensory cell. Fig. 1 shows the typical 9 + 2 structure of the kinocilium in a transverse section through a hair process. In our search for a possible asymmetry in the structure of the hair process as a whole, we paid special attention to the position of the kinocilium within the hair bundle and also with respect to its orientation relative to the crista of a semicircular canal. There is no doubt that the hair processes, are in fact, morphologically 'polarized'. The kinocilium is always found on one and the same side of the hair process in a given sensory epithelium. What is more, we found it possible to ascertain that the kinocilium is placed on that side of the sensory hair process which faces towards the utriculus in the crista of the horizontal and away from the utriculus in the crista of the anterior vertical canal (Fig. 2). This means that in both cases the kinocilium lies on that side of the hair process which faces in the direction of displacement when the cupula undergoes excitatory deflexion. It may be recalled that utriculopetal endolymph action produces excitation, utriculofugal endolymph action inhibition in the ampulla of the horizontal canal, whereas utriculo-petal endolymph action is inhibitory and utriculo-fugal action excitatory in the case of the ampullæ of the vertical semicircular canals.

It appears to us that this correlation between morphological and functional asymmetry in the end-structures of the sensory cells may pave the way to a better understanding of the events intervening between the mechanical and electrical changes involved in the elaboration of directional information.

The investigations were carried out in the Laboratory of the Marine Biological Association, Plymouth, in the Department of Zoology and Comparative Physiology, Birmingham; and in the Histology

Department of the Karolinska Institute, Stockholm. We were supported by grants from the Browne Fund of the Royal Society and by a grant from the Karolinska Institute. We are also indebted to the Department of Electron-Physics of the University of Birmingham for the use of the electron-microscope and for technical services.

A full account of the work which also comprises a study of the minute innervation of the hair cells and other cytological characteristics will be published elsewhere.

O. Lowenstein

Department of Zoology
and Comparative Physiology,
University of Birmingham.

J. Wersäll

Department of Histology,
Karolinska Mediko-Kirurgiska Institute,
Stockholm.

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HÆMATOLOGY

Decrease in Acid Strength of Propionate Side-chains of Hæmatin on Reduction to Hæm

That the hæm carboxyl groups might participate in reactions of hæmoproteins has received little attention, apparently because they were considered[1,2] to be too far away to be affected by addition of ligands to the iron atom. It was suggested[3] that the acid strength of hæm propionate side-chains might change, on the basis that substitution of R in RCH_2CH_2COOH has a significant effect on the pK value[4] and that any alterations in the high state of resonance of the porphyrin ring system was likely to have the same effect as substitution of R. Further, since side-chain variation has a marked influence on the oxidation-reduction potential of the iron of hæmochromes[2], it is, conversely, not unreasonable to expect that a change in electronic structure of the iron atom could effect the acid strength of the propionates.

Experiments indicating that a change in acid strength of at least one of the propionates does occur on reduction have now been carried out. Hæmatin and hæm combine with native human serum albumin through their propionate groups, not through their iron atoms[5]. The extent of combination may be studied by measuring the absorbance increment (at the Soret peaks of the compounds formed) after equilibrating the metalloporphyrin and protein in buffer solutions, separately and together, at 21° for 3–4 hr. (Fig. 1). The increment represents $A_{ha} - A_h - A_a$, where A = absorbance, h = hæmatin or hæm, a = albumin.

The decreased absorbance increment of the ferrohæmalbumin occurs whether the reducing agent (dithionite) is added initially or after the ferrihæmalbumin has formed. No appreciable amount of verdohæm-type compounds was detected, except, as expected, when attempts were made to reoxidize the ferrohæmalbumin solutions.

That the effect resulted from reduction of the hæmatin and was not due to either interference by the reducing agent itself or to its effect on the albumin

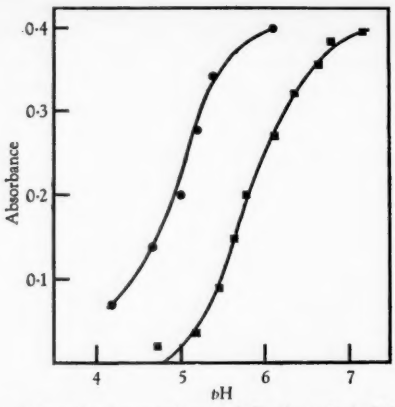

Fig. 1. Absorption increment curves indicating extent of attachment of hæmatin and hæm to human serum albumin. ●, hæmatin; +, albumin, measured at 404 mμ; ■, hæm + albumin measured at 414 mμ. (Hæmatin and hæm, $2{\cdot}86 \times 10^{-6} M$; albumin 2·5 per cent; 10 mm. curette. Buffers, pH 4·2–6·2 phthalate, 6·2–7·2 phosphate; $I = 0{\cdot}05$; $T = 21°$; time for equilibrium, 3 hr.)

was demonstrated by using nickel mesoporphyrin (unaffected by dithionite under these experimental conditions) with the albumin. On adding reducing agent, no significant change in attachment occurred.

Hæmatin couples to caffeine in the neutral pH range[6] and the extent of this attachment is also markedly decreased (by about 75 per cent at pH 7·0) on reduction to hæm. Linkages of this type are most likely to involve the propionate groups. Theophylline, having an unsubstituted imino group, is comparable with the imidazole side-chain as it would be expected to occur in proteins. In a preliminary single series of experiments, theophylline produced increments in the hæmatin Soret peak, but on reduction no absorbance increment was detected. These experiments indicate that the hæm propionate groups may play a very important part in the reactions of hæmatin compounds.

J. E. O'Hagan

Red Cross Transfusion Service,
Brisbane, Queensland.

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PATHOLOGY

Loss of Plasticity of Erythrocytes coated with Incomplete Antibodies

Teitel and Rădulescu were the first to describe in 1952 a method for evaluating the plasticity of red blood cells from their ability to pass through filter paper. Here we have used a modification of this method.

2 ml. of washed erythrocytes are placed in a funnel lined with filter paper (Schleicher Schül Nr. 589 'Schwartzband'), previously wetted with saline. The red cells although much greater in diameter than the pores in the paper do pass through[1], due to their

'plasticity'. This property also explains the ability of erythrocytes to circulate in the tiniest capillaries of the body.

The volume of filtered erythrocytes plotted as function of time on semilogarithmic paper, gives a straight line, representing the 'filtration speed', which parallels the erythrocyte plasticity.

O D + erythrocytes from the same bleeding are then sensitized *in vitro* with incomplete antibodies by incubating samples from a 50 per cent suspension of washed red cells with equal volumes of a series of dilutions (1/10, 1/20, 1/40, 1/80, 1/160, 1/320) of a serum containing incomplete anti-D antibodies. After 2 hours' incubation the erythrocytes are throughly washed and the presence of adsorbed antibodies checked both by the quantitative antiglobulin test and by treating the cells with papain.

The filtrability test is then performed as previously described and results are recorded during 16 minutes (Fig. 1). The ratio of the area under the curve for each

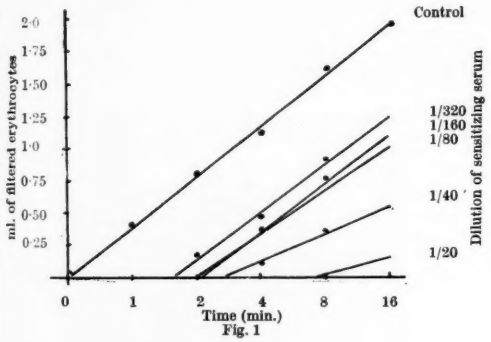

Fig. 1

sensitized erythrocyte sample is expressed as a percentage of the area under the curve for non-treated cells. As control, non-treated cells were incubated for 2 hours in exactly the same conditions as cells undergoing sensitization. The results express the 'erythrocyte plasticity' and are compared in Table 1 with the serological findings.

Table 1

Dilution of sensitizing serum	1/10	1/20	1/40	1/80	1/160	1/320	Control
Dilution of adsorbed anti-globulin serum :							
1/2	4 +	4 +	4 +	3 +	1 +	±	—
1/4	4 +	4 +	4 +	2 +	1 +	±	—
1/8	4 +	4 +	3 +	2 +	1 +	—	—
Papain test ..	4 +	4 +	4 +	4 +	4 +	3 +	—
Percentage plasticity	0	0·71	15	34	34	41	100

4 + to ± = Different degredes of agglutination.
— = No agglutination.

4 + to ± = Different degrees of agglutination. — = No agglutintaion.

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After sensitization erythrocytes lose some of their plasticity. This loss of plasticity roughly parallels the amount of sensitizing antibody and may possibly explain the selective trapping of sensitized cells by the spleen.

C. T. Nicolau
P. Teitel
M. Fotino

Laboratoarele de Biochimie şi de Serologie,
Centrul de Hematologie şi Transfuzie,
Bucureşti, str. Dr. Felix nr. 89.

Fate of Subcutaneous Thymus Grafts in Thymectomized Mice inoculated with Leukæmic Filtrate

Murine lymphocytic leukæmia, whether spontaneous or induced by ionizing radiations or chemical carcinogens, cannot develop in the absence of thymus tissue[1]. It has recently been shown that the early leukæmia produced in *Ak* mice by the inoculation of leukæmic filtrate at birth can be prevented by total thymectomy[2]. A similar inhibition of leukæmogenesis has been reported in *C3H* mice[3].

C3Hf/Gs mice were obtained from Gross in 1958 and have been inbred in our laboratory since then. Passage *A* leukæmic filtrate was prepared by Gross's method[4] from mice the leukæmias of which had been induced by Gross himself. This preparation has given us 100 per cent leukæmias at 2–4 months of age after inoculation into newborn or suckling *C3Hf/Gs* mice[5].

The results of two separate experiments will be described here. In experiment I, *C3Hf/Gs* mice between 1 and 5 days of age were treated as follows : all the mice were inoculated with passage *A* filtrate except one or two in some of the litters which were kept as controls, being tail-clipped for identification and receiving filtrate that had been heated to 56°C. for 30 min. At 3–4 weeks of age, about half the mice inoculated with fresh filtrate were thymectomized. The results are given in Table 1. All 24 inoculated non-thymectomized mice developed the disease between two and four months of age. None of the 7 controls nor any of the 22 thymectomized littermaters has yet developed the disease. They are now more than twelve months of age.

Table 1. Experiment I. Effect of Thymectomy in *C3Hf/Gs* Mice Inoculated with Passage *A* Filtrate

Treatment	Total No. of mice	No. of mice with leukæmia	Leukæmia incidence (percent)
Passage *A* injected at birth	24	24	100
Passage *A* at birth : thymectomized	22	0	0
Control	7	0	0

In experiment II, two groups of *C3Hf/Gs* mice were studied. In the first group, the mice were untreated at birth, thymectomized at four weeks of age and grafted subcutaneously from one to thirty days after thymectomy with normal day-old isologous thymus. In the second group, the mice received passage *A* filtrate at birth, were thymectomized at four weeks of age and grafted from one day to six months after thymectomy with a whole thymus from a normal, untreated, newborn *C3Hf/Gs* mouse. Each mouse received one whole thymus which was

introduced, with strict aseptic precautions, into the subcutaneous tissues of the right or left axilla by means of a trocar and cannula. The results are shown in Table 2. It will be seen that whereas none of the thymuses grafted to uninoculated thymectomized mice developed lymphoid tumours, 50–100 per cent of those grafted between one day and six months after thymectomy became malignant in thymectomized inoculated mice. Some of these thymomas afterwards disseminated as generalized lymphocytic leukæmia. The survivors in this experiment are 10–12 months old.

Table 2. Experiment II. Incidence of Lymphoid Tumours in *C3Hf/Gs* Thymuses grafted to Thymectomized Mice

Group	No. of mice in group	Filtrate given at birth	Age at thymus grafting	No. of mice with lymphoid tumours and age at time of diagnosis
I	20	None	1–2 months	0
II	10	Passage A	1 month	10 (3–4 months)
	18	Passage A	2–3 months	15 (3–5 months)
	12	Passage A	3–4 months	9 (5–8 months)
	11	Passage A	7 months	6 (9–11 months)

The results confirm the previous reports[2,3] that thymectomy prevents leukæmogenesis by cell-free leukæmic extracts. They show, however, that the potentiality for development of leukæmia is still present in the thymectomized animals and that normal isologous thymuses from untreated, healthy, day-old mice can express this potentiality when grafted to the subcutaneous tissues of the inoculated hosts as late as six months after thymectomy. It follows from this that the leukæmic agent cannot be stored principally in the thymus and that thymectomy does not act by simply removing the source of the agent. Whether thymectomy prevents leukæmia development by removing from the body the only type of cells in which the agent can reach a concentration high enough to induce leukæmia, or by removing the cells most susceptible to leukæmic transformation, or by removing the source of a humoral factor involved in leukæmogenesis remains to be determined. Experiments are now in progress in an attempt to settle these questions.

I am greatly indebted to Dr. Ludwik Gross for sending me his strain of *C3H* mice and some mice with passage *A* induced leukæmias. I am also indebted to a scholarship from the University of Queensland, Brisbane and to Profs. A. Haddow and P. C. Koller for their interest. The investigations have been supported by grants to the Chester Beatty Research Institute (Institute of Cancer Research: Royal Cancer Hospital) from the British Empire Cancer Campaign, the Jane Coffin Childs Memorial Fund for Medical Research, the Anna Fuller Fund, and the National Cancer Institute of the National Institutes of Health, U.S. Public Health Service.

J. F. A. P. Miller

Chester Beatty Research Institute,
Institute of Cancer Research,
Royal Cancer Hospital,
Fulham Road, London, S.W.3.
Nov. 17.

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Pure Culture of the Pathogenic Agent of Tyzzer's Disease of Mice

For some years repeated epizootics of a hepatic disease have been noticed among a few breeding colonies of mice in Japan. Because the main features of this disease is indistinguishable from the original descriptions of Tyzzer[1] as well as those of Saunders[2] the disease in question will be referred to as Tyzzer's disease. We investigated recently this disease found in *dd* and CF_1 strain of mice, and succeeded for the first time in obtaining a pure culture of the causative organism, *Actinobacillus piliformis*[3].

Culture media : Liver extract, 1000 ml.; polypeptone, 10 gm. sodium chloride, 5 gm.; agar, 20 gm. Minced liver is extracted with two volumes of tap water at 100°C. for 1 hr. After melting, *p*H is adjusted to 7·8 with sodium hydroxide solution. Autoclave at 15 lb. for 15 min. Not only the mouse liver but also rabbit or ox liver can be utilized as source material. Curiously enough, Tyzzer himself had tried without success the same type of culture media some forty years ago.

Pure culture : When a bit of liver with lesions is streaked over a liver extract agar slant, semi-transparent droplet-like colonies can be observed after 24–48 hr. of incubation at 37°C. The colony has a prominence in the centre and is somewhat raised at the periphery (Fig. 1). Positive cultures were obtained

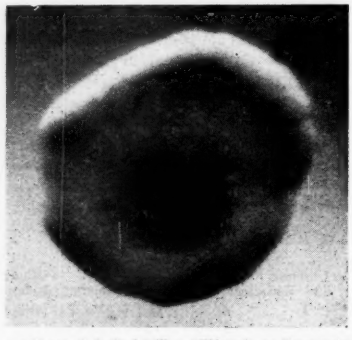

Fig. 1. A colony of *Actinobacillus piliformis* on liver extract agar

in about 70 per cent (46/66) of liver materials with various grades of lesions. This organism can be readily subcultured on liver extract agar but no growth appears on plane or blood agar. However, they grow on plane agar with 0·1 per cent cysteine or Loeffler's serum after several transfers on liver extract agar. Microscopically this organism is very pleomorphic. It stained well with Giemsa solution and non-acid fast. Gram stain was irregular in depth: it stains not strictly positive but not always negative. Among Gram-negative small longer rods often assume a violet tint interposed among the Gram-negative short band or bands. They produce acids without gas from dextrose, lactose, sucrose, maltose and less markedly also from mannitol, xylose, rhamnose and raffinose. With respect to spore formation we agree with the opinion of Rights and his collaborators[4] since we could not confirm a definite spore in stained smears nor heat resistance of cultured organism; growth on liver extract agar kept at room temperature for about 10 days lost its viability and the organism in suspension was killed by heating at 60°C. for 10 min. The organism when freeze-dried with skim-milk or horse serum can be kept alive for at least one month.

Experimental infection : In order to illustrate the pathogenicity of the cultured agent, we used *dd* strain of mice free from Tyzzer's disease obtained from another breeding colony and conducted experiments under strict bacteriological control of rooms, cages, diet and manipulations. One of the experiments is described below. 0·2 ml. each of a suspension (2 mgm./ml.) of the cultured organism (strain No. 3 at the 12th transfer on liver extract agar was injected into the tail vein of 3-week-old mice. 18 mice were inoculated and 20 mice were kept aside as controls. A majority (17–18) of mice developed diarrhœa around two weeks after inoculation and 16 of 18 mice died between 15th and 41st day all showing liver lesions. One of two survivors also had diarrhœa for several days. A few small lesions were noted in cases of early death and numerous typical large lesions with darker central regions were observed in three later fatal cases. Histological findings of these liver lesions as well as characteristic intracellular organisms lying parallel to one another are quite comparable with those of natural infection. All the control mice remained normal for two months. After they were killed, no lesions were found in the liver.

Meanwhile, intracerebral inoculation of a emulsion of liver with typical lesions from a naturally infected mice was effected in *dd* mice. In accordance with Rights *et al.*[4], 8 out of 10 mice thus infected showed cerebral symptoms and died between the 3rd and 8th day. From the brains of six dead mice available for study the agent was found both on stained smears and by culturing on liver extract agar. One of the established cultures from the infected brains was inoculated in turn intracerebrally in mice at its second transfer on liver extract agar, and this time only 3 out of 7 mice died with moderate recovery of the agent on liver extract agar. On the other hand, intracerebral inoculation of three strains of cultured organism isolated from liver lesions, after several transfers on liver extract agar, failed to induce obvious disease in mice (0–18).

Serological studies : Rabbit immune serum was prepared by three intravenous injections of suspension of the cultured organism (strain No. 1 and 3). Using these two sera, all the strains tested thus far (11 strains isolated from liver lesions and 2 strains from infected brains) were identified by the complement fixation test. Moreover, the complement fixation test was conducted using normal and infected mouse liver emulsions as antigen in hopes of elucidating the serological relationship between the cultured organism and the mouse infection. In the latter experiment, No. 3 serum (1:5) was inactivated at 65°C. for 20 min. Saline emulsion (1:8) of liver with typical lesions obtained from both naturally and experimentally infected mice was heated at 100°C. for 5 min. and then centrifuged. Two full units of complement were used as routine. The results are shown in Table 1.

TABLE 1

Liver antigens	Dilutions 8	16	32	64	Antigen Control	Serum Control
Control	0†	0	0	0	0	0
Natural infection	4†	2	1	tr	0	
Experimental infection*	4	3	3	1	0	

* Obtained from a mouse infected with the cultured agent strain No. 3 at the 19th transfer on liver extract agar.
† 0, complete hæmolysis ; 4, no hæmolysis.

Sensitivity to antibiotics : Four strains of the cultured organism were tested for their sensitivity to various antibiotics by the liver extract agar dilution method. The results of four strains were quite comparable and the minimal inhibitory concentrations were found as follows (μgm./ml.) : penicillin, 0·5 ; streptomycin, 10 ; kanamycin, >100 ; neomycin, 100 ; tetracycline, 50 ; cycloserine, >200 ; chloramphenicol, 4.

We think the ætiology of the epzootic hepatitis has now been clearly established ; but acceptance of our findings must await further experimental proof in other epizootics of Tyzzer's disease anywhere.

K. KANAZAWA
A. IMAI

Takeda Research Laboratories,
Juso, Osaka, Japan.
Aug. 14.

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Iso-Antigens of Rabbit γ-Globulin

IN 1902 Schütze[1] reported that by injecting pooled rabbit sera into a rabbit iso-precipitins were produced which reacted with some rabbit serum antigens. However, this work was not followed up.

A few years ago Oudin[2,3] showed that rabbits can also produce iso-precipitins when immune precipitates, formed by an antigen and corresponding rabbit antibody, were injected. He described 9 rabbit serum groups and called the variation of serum antigens 'allotypy'. Following his investigations Dray and Young[4,5] injected rabbit sera together with paraffin-oil type adjuvants into rabbits, and were able to classify rabbits into 13 serum groups. These iso-precipitins reacted with serum antigens having electrophoretic mobilities of α-, β-, and γ-globulins.

Working independently on this problem Dubiski *et al.*[6] produced iso-precipitins in rabbits using a different technique ; the animals were inoculated intravenously with bacterial cells coated with corresponding rabbit antibodies. The authors could distinguish 2 rabbit serum (γ-globulin) groups, D(a+) and D(a−), and could show the inheritance of the D^a antigen and its non-genetic transfer from mother to infant. The present communication is a continuation of their work.

For antibody production the rabbits were immunized with killed *Proteus vulgaris* X19, or *Salmonella typh-murium*, or *Streptococcus pyogenes*. Other rabbits were then injected with bacterial cells coated with these antibodies as reported previously[6]. Using this method we obtained 22 anti-sera reacting in various ways with rabbit serum antigens in agar gel plates and the ordinary tube precipitation reaction. Some of these anti-sera formed a very strong precipitate and were analysed in detail. At least 4 different antibodies were identified. We call them ; anti-A (formerly anti-D^a), anti-B, anti-C and anti-D ; the corresponding serum iso-antigens are : A (formerly D^a), B, C and D. (Prof. J. R. Marrack kindly examined the antigen-antibody systems immunoelectrophoretically and established that the antigens are of γ-globulin mobility.)

Sera of 6 separate rabbit populations (630 individuals) were tested. The results are summarized in Table 1.

Among the population 'Rokitnica', in which not all animals are related and many were purchased from the market, four antigens occur. In the cross-bred populations 'Big *R*' and 'Veterinary' the C

Table 1. Distribution of rabbit γ-globulin antigens

Antigen	Rabbit population: Poland Rokitnica	Big *R*	England Veterinary	England Pathology	*RSH*	*RSJ*
A	(32) 0·129	(14) 0·184	(20) 0·345	0	0	0
B	(67) 0·269	(12) 0·158	(7) 0·121	(22) 0·140	0	0
C	(23) 0·092	0	0	0	0	0
D	(192) 0·771	(55) 0·724	(22) 0·379	(146) 0·930	(35) 1·000	(55) 1·000
Absent (abcd)	(28) 0·112	(8) 0·105	(15) 0·259	(4) 0·025	0 35	0 55
Total	249	76	58	157		

The figure in parentheses gives the number of animals. The other figure gives the antigen frequency.

antigen is absent, while in the cross-bred population 'Pathology' the antigens B and D are present. The populations '*RSH*' and '*RSJ*' (the strains *H* and *J*) are most interesting because only the D antigen occurs. These are random mating strains started many years ago by Dr. J. Hammond.

It is theoretically possible by use of 4 anti-sera to distinguish 16 groups (γ-globulin groups). Table 2 illustrates that, to date, 13 groups only have been demonstrated.

Several rabbit families, including a large family of 4 generations (55 individuals), from the 'Pathology' population were also tested. The hereditary character of the B and D antigens was established.

Recently a fifth antibody, anti-E, and corresponding serum antigen E was found. Its frequency in the 'Rokitnica' population is 0·538. This antibody makes it possible to distinguish 32 rabbit serum groups (21 groups have been identified so far). The E antigen is also present in the 'Pathology' population.

We succeeded also in immunizing rabbits of the abcD group against sera of other abcD individuals. The analysis of these antibodies is now in progress.

Lately Dr. Dray kindly sent us the anti-I and anti-II sera. The anti-I serum was analyzed and demonstrated that it possesses anti-A antibody.

More complete results and analysis of our experiments will be published elsewhere.

We should like to point out that the described antigens are in the γ-globulin fraction of serum in which most antibodies are found. These γ-globulin antigens can be at the same time antibodies to hetero-antigens, that is, to bacteria, animal and plant cells, etc. This phenomenon is not only of great interest to serologists and immunochemists but may be of use to geneticists in providing another set of hereditary markers. One advantage is that not only the anti-sera but the antigens as well can be stored for many years.

We are very grateful to Prof. J. R. Marrack and Dr. R. R. A. Coombs for stimulating discussion, and to Drs. Elaine Rose and C. E. Adams for permission to examine their rabbits. One of us wishes to thank the Administrators of the H. E. Durham Fund for the grant which made this work possible.

S. Dubiski
Danuta Skalba
Anna Dubiska

Institute of Microbiology,
Silesian School of Medicine,
Zabrze-Rokitnica, Poland.

A. Kelus

Department of Pathology,
University of Cambridge.

Sept. 23.

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Table 2. Distribution of rabbit γ-globulin groups

Reaction with anti-sera: anti-A	anti-B	anti-C	anti-D	Group	Rabbit population: Rokitnica	Big *R*	Veterinary	Pathology	*RSH*	*RSJ*
+	+	+	+	ABCD	0	0	0	0	0	0
+	+	+	−	ABCd	0	0	0	0	0	0
+	+	−	+	ABcD	(8) 0·032	0	0	0]	0	0
+	+	−	−	ABcd	0 (2)	(3) 0 0·039	0	0	0	0
+	−	+	+	AbCD	0·008	0	0	0	0	0
+	−	+	−	AbCd	0	0	0	0	0	0
+	−	−	+	AbcD	(19) 0·076	(5) 0·066	(4) 0·069	0	0	0
+	−	−	−	Abcd	(3) 0·012	(6) 0·079	(16) 0·276	0	0	0
−	+	+	+	aBCD	(3) 0·012	0	0	0	0	0
−	+	+	−	aBCd	(4) 0·016	0	0	0	0	0
−	+	−	+	aBcD	(33) 0·133	(5) 0·066	(2) 0·034	(15) 0·096	0	0
−	+	−	−	aBcd	(19) 0·076	(4) 0·052	(5) 0·086	(7) 0·045	0	0
−	−	+	+	abCD	(11) 0·044	0	0	0	0	0
−	−	+	−	abCd	(3) 0·012	0	0	[0	0	0
−	−	−	+	abcD	(116) 0·466	(45) 0·592	(16) 0·276	(131) 0·834	(35) 1·000	(55) 1·000
−	−	−	−	abcd	(28) 0·112	(8) 0·105	(15) 0·259	(4) 0·025	0	0
Total					249	76	58	157	35	55

Lymphoid Necrosis Induced by Lipid Emulsions

LYMPHOID tissue exposed to certain lipid emulsions undergoes a gross and widespread necrosis, while exposure either to the lipid or emulsifier alone produces only minor 'reactive' changes. This phenomenon, which, so far as we know, had not been previously reported, was first described by one Bennett and Shivas[1]. Further work still in progress has shown that necrosis can be produced by a wide variety of lipid emulsions and the effect appears to be a general property of these. Emulsions containing 20 per cent w/v ethyl stearate, ethyl laurate, '*F* 99' (a preparation of ethyl esters of linoleic and linolenic acids), stearic acid, lauric acid, olive oil and liquid paraffin have been given in a single dose of 2 ml. to fully grown young rats by the intraperitoneal route under direct vision at laparotomy with ether anæsthesia. The emulsifiers used are 'Tween 80', ox bile and gum acacia. Glyceryl monostearate emulsions were prepared without any added emulsifying agent. Unemulsified lipids and aqueous solutions of emulsifying agents (with the exception of ox bile) have also been administered separately at concentrations equivalent to those in the emulsions.

Operative mortality is negligible and the animals, which are killed at intervals of 1–8 days after injection, are no more indisposed than might be expected from the anæsthesia and trauma. Necrosis found in the slightly enlarged mediastinal lymph nodes which constitute the regional drainage varies in extent and severity with the individual emulsion, being most severe with ethyl stearate (Figs. 1 and 2). The maximum effect is attained about 5 days after injection. 'Reactive' changes resulting from the lipids or emulsifiers given alone consist chiefly of a dilatation of the sinuses which become filled with large mononuclears looking like macrophages (Fig. 3). In both necrotic and non-necrotic lymph nodes a very interesting feature is the alteration in morphology of surviving cells reminiscent of that described by the Gillmans[2] in their work with trypan blue and of the 'hepatic microgranulomas' in dogs given intravenous fat emulsion reported by Meyer *et al.*[3] After severe necrosis (Fig. 2) regeneration seems to proceed from fibrocellular elements which presumably escape necrosis. The necrotizing action thus appears selective and there have been no adhesions in the peritoneal cavity or evidence of damage other than to lymphoid tissue.

These findings pose many questions which cannot yet be answered. Nevertheless, it seems reasonable to conclude that the action of the emulsions in producing necrosis is to a large extent independent of the nature of the lipid used. Occurring with free and esterified fatty acids both saturated and unsaturated, with the hydrocarbon oil liquid paraffin and with the 'essential' fatty acids, it would seem to depend primarily on their physical state. Although the actual mechanism is quite obscure and much work remains to be done, the lipid emulsions may well provide a new research tool for investigation of the reticuloendothelial system and it is with this hope that we venture, by this interim report, to bring it to the notice of workers in all fields of biological research.

A. A. SHIVAS
G. P. FRASER

Department of Pathology,
University of Edinburgh.

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RADIOBIOLOGY

Concentration of Cæsium-137 in the Coastal Waters of Japan (1959)

I HAVE analysed bittern and carnallite of industrial origin and deduced the concentration of cæsium-137 in the coastal waters in early 1958 of Japan as 70–150 μμc. kgm./l.[1] Recently, by application of a low-level β-counting equipment, cæsium-137 has been successfully determined by direct treatment of 6–20 litres of sea-water.

Separation of 20 mgm. of carrier cæsium which had been originally added to the sample water was

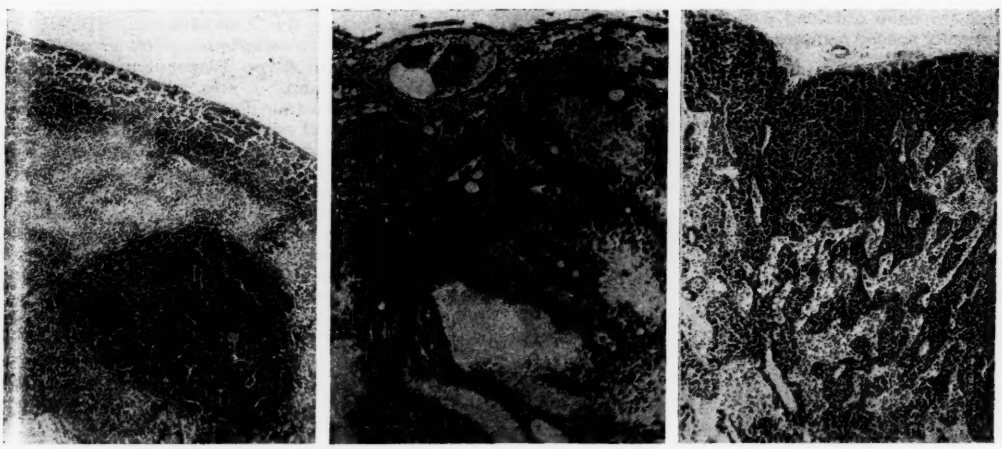

Fig. 1 (left). Early necrosis in a mediastinal lymph node 1 day after intraperitoneal injection of an emulsion of ethyl stearate. The darkly-staining areas are surviving normal lymphoid tissue (H. and E. ×*c.* 60). Fig. 2 (centre). Large tracts of amorphous necrotic debris six days after injection of the emulsion. Note the proliferation of fibrocellular tissue and the small area of surviving lymphoid tissue (left of centre) (H. and E. ×*c.* 50). Fig. 3 (right). Mediastinal lymph node 8 days after intraperitoneal injection of olive oil. Note the dilated sinuses crowded with mononuclears of macrophagic appearance, and the absence of necrosis (H. and E. ×*c.* 60)

achieved by the phosphomolybdate-chloroplatinate method[2] with a slight modification. The precipitate of cæsium ammonium phosphomolybdate was dissolved in ammonia water and the solution was run through a column of anion exchange resin (OH-form). The effluent was evaporated to expel ammonia and the residue was dissolved in water with several drops of hydrochloric acid. Cæsium was then reprecipitated as chloroplatinate in aqueous medium.

Chemical yield was about 80 per cent and radiochemical purity of the final precipitate is supposed to be more than 95 per cent. Blank determinations with pure water and cæsium for the whole separation procedure yielded no radioactivity assignable to cæsium-137. Standard error given in Table 1 is of counting fluctuation and the error for the over-all procedure is supposed to be approximately 10 per cent.

The coastal surface water was collected principally from salt-works where the sea-water is directly pumped up into a vacuum evaporator and is never exposed to the open air. The cæsium-137 concentrations and other pertinent data for fourteen surface sea-water samples are presented in Table 1. Fig. 1 shows approximate sampling position.

Table 1. Concentration of Cæsium-137 in the Coastal Waters of Japan (1959)

Location No.	Name	Position	Date (1959)	Chlorinity (o/oo)	Cæsium-137 ($\mu\mu$c./kgm.)
1	Monbetsu	44°39′N 144°01′E	VI 1	18·87	0·29±0·012
2	Horobetsu	42 04 141 26	VI 1	17·65	0·23 0·009
3	Ōfunato	39 02 141 44	V 21	19·70	0·25 0·015
4	Senami	38 34 139 46	V 16	18·87	0·39 0·019
5	Onahama	36 56 140 54	V 20	19·47	0·24 0·014
6	Kurobe	36 52 137 25	V 20	19·39	0·33 0·016
7	Chōshi	35 42 140 50	III 20	19·33	0·55 0·029
	,,	(duplicate determination)			0·55 0·036
8	Kawazu	34 44 139 00	V 26	18·96	0·31 0·016
9	Ibuki-jima	34 07 133 34	IV 6	18·83	0·62 0·048
10	Shirahama	33 41 135 20	V 22	19·60	0·38 0·018
11	Emukae	33 36 129 36	V 25	19·46	0·42 0·017
12	Sakito	33 01 129 34	V 26	19·67	0·31 0·010
13	Ōmuda	32 55 130 25	V 28	17·85	0·35 0·017
14	Ibusuki	31 14 130 40	V 20	19·50	0·65 0·026

The samples other than No. 7 and 9 were collected during the short period May 16–June 1. A trend may be observed among these samples; the concentration of cæsium-137 is rather low in the coastal waters of Hokkaidō and north-eastern Honshū (No. 1, 2, 3 and 5). I feel this trend could be explained in terms of two different tidal currents around Japan, that is to say, Kuroshio and Oyashio. However, a definite explanation cannot be given until we have obtained some series of oceanic and vertically spaced samples.

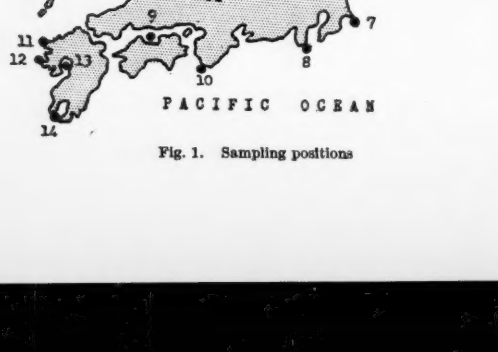

Fig. 1. Sampling positions

The average of the concentration of cæsium-137 on the whole samples of 1959 is calculated to be 0·38 $\mu\mu$c. per kgm. of surface sea-water, which indicates an increase by a factor of more than two as compared with the concentration deduced in early 1958.

The average daily intake of cæsium-137 by a Japanese in the period August 1957–August 1958 was determined by me and co-workers to be 22–56 $\mu\mu$c.[3] The contribution of cæsium activity from marine products to the whole diet has been considered negligible because of high dilution of cæsium-137 by the vertical mixing of sea-water. Cæsium will be strongly discriminated in food-chains on land, especially from soil to plants. However, in aqueous medium as in sea-water, on account of the strongly ionic nature of this element, cæsium will freely move and enter the marine animals and plants with less discrimination. From this reason, when considering the growing levels of concentration in sea-water, the cæsium activity of marine products in the whole diet must not be minimized until the vertical and the horizontal mixing of sea-water compensate, especially for Japanese people for whom marine products are the principal sources of proteins.

Noboru Yamagata

Institute of Public Health,
Tokyo.

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Importance of the Type of Metabolism for the Radiosensitivity of Mice

We have already reported on reduced radiosensitivity of mice pre-treated with dried thyroid gland[1]. Attempts were made to correlate these changes of radiosensitivity with the qualitative state of metabolic processes. The work was performed on the thyroid pre-treated mice and on the groups of normal irradiated mice.

The measuring of gaseous exchange was used and the respiratory quotient was evaluated ($R.Q.$ = carbon dioxide output : oxygen consumption[2,3]). The respiratory quotient was measured in the groups of 3–5 mice 1 hr. before the X-irradiation. The doses of single total-body irradiation of 600 r. and 450 r. respectively, were given (Super Sanax apparatus, 180 kV., 15 m.amp., 1 mm. aluminium, 0·5 mm. copper, target distance 43 cm., 60 r. per min.). White male mice of mean weight 30 gm. were used.

The results of experiments with thyroid pre-treated mice, irradiated with 600 r. are summarized in Table 1. It is evident, that the best radioprotective effect in series I and II is connected with an elevation of the $R.Q.$ into the values indicating an increase of lipogenesis. In series III, where there are no significant differences in the mortality, no considerable elevation of $R.Q.$ is observed.

Table 1

Series	Thyroid pre-treated mice			Control mice		
	No. of mice	Percent of thirty day survival	Average $R.Q.$	No. of mice	Percent of thirty day survival	Average $R.Q.$
I	33	66*	1·25*	35	0	0·97
II	37	54*	1·10	52	15	0·93
III	22	13	0·82	49	0	0·80

* Significantly different from controls ($P<0·01$).

In the second part of experiments, the relation of spontaneous variability of $R.Q.$ to the radioresistance of normal mice irradiated with 450 r. was observed.

Table 2

Group	No. of mice	Percent of thirty day survival	Average *R.Q.*
A	25	80	1·10
B	75	36	0·97
C	47	19	0·75

The *R.Q.* values were found to be of group character. Table 2 shows that there exists a relation of mean *R.Q.* values of groups to their mortality after irradiation. The most radioresistant were the mice of increased lipogenesis (group *A*). On the contrary the most radiosensitive mice where those of increased utilization of fats (group *C*). The statistical significance was proved not only between the mortality of the groups ($A-B$: $P<0{\cdot}01$; $A-C$: $P<0{\cdot}01$; $B-C$: $P<0{\cdot}05$), but also between the mean *R.Q.* values of the groups ($A-B$: $P<0{\cdot}05$; $A-C$: $P<0{\cdot}001$; $B-C$: $P<0{\cdot}001$).

Our results indicate that the favourable effect of thyroid pre-treatment is probably conditioned by the functional hypoactivity of the thyroid, induced by the thyroid feeding. Hyperthyreosis, on the contrary, reduces the lipogenesis from carbohydrates[4]. The favourable effect of lipogenesis and the unfavourable effect of increased utilization of fats in the time of irradiation may be in relation to the well-known prognostic value of lipæmia[5] and to the disturbances in the fat metabolism observed after irradiation of animals[6].

M. Pospisil
L. Novák

Institute of Biophysics,
Czechoslovak Academy of Sciences,
Tr. Obráncu míru 10,
Brno,
Czechoslovakia.

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Abrogation by Injected Mouse Blood of Protective Effect of Foreign Bone Marrow in Lethally X-Irradiated Mice

It was observed recently[1] that intraperitoneal injection of whole blood or of leukocytes from parental strain mice (*A* or *C*57 strains) into sublethally X-irradiated $(L\times A)F_1$ hydrid mice results in marked lymphoid atrophy and delayed deaths in these recipients. Similar effects have been observed after administration of lymphoid tissue cells of the parental strain (spleen, lymph node) under the same conditions[2]. These results suggested that peripheral blood contains cellular elements which are capable of immunological reactivity. According to this view, the recipient mice succumb as a consequence of a donor-to-host homograft reaction, initiated by the injected blood cells or their progeny. Furthermore, earlier work[3] had shown that injection of isologous lymphoid tissue cells (from spleen or thymus) a few hours after lethal X-irradiation of mice elicits the early rejection of rat marrow transplants, whereas such grafts ordinarily 'take' in lethally X-irradiated mice. (Isologous—from the same inbred strain; homologous—from the same species, but different genotype; heterologous—from a different species.) It was, therefore, of interest both theoretically and from a practical point of view, to determine whether the administration of normal whole blood would similarly cause rejection of foreign bone marrow transplants in X-irradiated mice.

The experimental procedure was as follows: Groups of $(L\times A)F_1$ hybrid mice 12–15 weeks old were exposed to a lethal dose of 250 kV. X-rays (870 r.). This was followed (within a few hours) by intravenous injection of fresh bone marrow cell suspension in Tyrode's solution—either 70×10^6 nucleated cells from Sprague-Dawley rats, or 5×10^6 cells obtained from C_3H strain mice. Subgroups of these marrow-treated mice, were given, at the same time, a single intraperitoneal injection of 0·6 ml. of fresh, pooled, heparinized cardiac blood (containing $3–4\times10^6$ nucleated cells) obtained from non-irradiated mice. The criteria of effect were mortality, survival time, and persistence and growth of the rat marrow grafts, as detected by the histochemical alkaline phosphatase reaction in tissue sections[4]. As is now well documented[5], survival of otherwise lethally X-irradiated mice injected with bone marrow cell suspensions is associated with persistence and growth of these cells, leading to re-population of hæmatopoietic sites in the host. In the present work, therefore, rejection or absence of 'takes' of the injected *mouse* bone marrow is inferred, when no protection against death is afforded, and when the survival time is not appreciably longer than that of the irradiated controls. Rejection of the *rat* bone marrow transplant is inferred from the survival data, and in addition by the absence of alkaline phosphatase positive cells.

Table 1. Abrogation by Normal Mouse Blood of Protective Effect of Foreign Marrow

All recipient mice (LAF_1) subjected to 870 r. X-irradiation.
Blood (0·6 ml.) was injected intraperitoneally; marrow intravenously.

Experiment No.	Treatment	Mortality (21 days)	(No./Total) (60 days)	Mean survival time (days)
1	Rat *BM** + irrad. LAF_1 blood	1/5	2/5	15, 53
	Rat *BM* + LAF_1 blood	10/10	—	9
	Rat *BM* + C_3H blood	10/10	—	11
	Tyrode's solution	8/8	—	11
2	C_3H *BM*	0/7	4/7	29
	C_3H *BM* + C_3H blood	1/10	7/10	31
	C_3H *BM* + LAF_1 blood	10/10	—	8
	Tyrode's solution	12/12	—	9
3	C_3H *BM*	1/10	1/10†	19
	C_3H *BM* + LAF_1 blood	11/11	—	12
	Tyrode's solution	9/9	—	13
4	LAF_1 *BM* + C_3H blood	7/9	9/9	19
	LAF_1 *BM*	0/3	—	—

* *BM* = bone marrow.
† At 35 days post-radiation.

The experimental results are summarized in Table 1. In the experiment with rat bone marrow (experiment 1), it is evident that the injection of 0·6 ml. of mouse blood (either isologous or homologous) resulted in the annulling of the protective effect of rat bone marrow. Furthermore, alkaline phosphatase positive cells (that is, rat granulocytes) could not be detected in the spleens taken from two moribund animals 7 days after injection of rat bone marrow and LAF_1 blood, or from moribund mice 11 days after rat bone marrow plus C_3H blood. On the other hand, large numbers of cells positive to alkaline phosphatase were found in the spleen and bone marrow of an irradiated mouse 39 days after injection of rat marrow plus inactivated LAF_1 blood (that is, blood obtained from mice exposed to 870 r. one hour before).

Turning to the experiments with homologous bone marrow (C_3H marrow into X-irradiated LAF_1 mice), it can be seen that when isologous blood (from the same strain as the recipients) was administered, clear-cut prevention of the protective effect of the marrow occurred. However, when the injected blood and marrow were derived from the same strain (C_3H in

experiment 2), there was no indication of prevention of C_3H marrow transplantation, as evidenced by the survival data, compared with the group given C_3H bone marrow alone. The limited results of experiment 4 suggest that the administration of normal homologous mouse blood (in this instance from C_3H strain) can, indeed, alter the course of transplantation of isologous marrow in lethally irradiated hosts. Note that in this group the mean survival time (19 days) was significantly increased, as compared with the mice injected with homologous bone marrow plus blood.

These experimental results provide further support for the presence of immunologically reactive cells in peripheral blood. Presumably, when injected under the experimental conditions described, such cells or their progeny come in direct contact with the donor bone marrow cells (of different geno-type from the injected blood cells), causing their rejection by a homograft type of reaction. As a result, the host animals succumb, as do control irradiated mice, from the sequelæ of marrow failure. In any event, regardless of the specific mechanisms involved, empirical evidence is given here for the deleterious effect of injected blood with respect to the protection of lethally X-irradiated mice by means of bone marrow transplantation. Although the present experiments deal with specific, inbred mouse strains, their possible implications for marrow therapy in irradiated humans[6] are evident.

This investigation has been supported in part by funds from the Bureau of Medicine and Surgery, U.S. Navy Department, and from the Office of Civil Defense Mobilization. The opinions and assertions contained herein are not to be construed as official or as reflecting the views of the Navy Department.

L. J. Cole
R. M. Garver

Biological and Medical Sciences Division,
U.S. Naval Radiological Defense Laboratory,
San Francisco 24, California.

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Effect of Whole-body X-Irradiation on the Insulin Resistance of Fasted Rats

An increase of the insulin resistance was observed in fasted adult albino rats if they previously were exposed to 600 r. of X-rays.

The number of animals which survived a lethal dose of insulin for 24 hr. was used as a measure of the insulin resistance. Rats of our laboratory strain were used. In the first group, 20 adult males were deprived of liver glycogen stores by withdrawing food for 46 hr. before the insulin was injected. 1 hr. before the injection animals were 'sham irradiated' and weighed. Body-weights were 250–350 gm. Insulin-zinc ('Prolek' Beograd, 40 U./ml.) was injected subcutaneously in the hind limb. The dose was 6 U./100 gm. body-weight. After the injection animals were kept fasting. All animals died in the interval between 2 hr. 55 min. and 6 hr. 15 min. after insulin injection.

The second group of 20 males was treated in the same way, except that they were irradiated 1 hr. before injecting insulin. They received 600 r. whole-body irradiation (measured in air), with 180 kV. X-rays (10 m.amp.). The dose was given 40 cm. from the target at 55 r./min. Filters used were 0·5 mm. copper and 1 mm. aluminium. In this group 14 animals died, the first one 3 hr. 10 min. and the last one 6 hr. after insulin injection. Six of the animals were alive 24 hr. after injection.

The same experiment was carried out with female rats which weighed 200–300 gm. before insulin injection. Of the control 'sham irradiated' group, 11 animals died. The first one died 4 hr. 45 min. and the last two died between 13 hr. and 22 hr. after the insulin injection. Of the females exposed 5 animals died, the first one 3 hr. 10 min. and the last two between 13 hr. and 22 hr. after the injection.

The results suggest that irradiated fasted rats were to a certain degree more resistant to insulin than animals which were fasted only, and that insulin resistance was more pronounced in the female than in the male rats. The influence of irradiation could be mediated through a 'contra-insular' effect of endogenous glucocorticoids, since hyperactivity of the adrenal cortex, especially in the first 24 hr. after exposure, has been repeatedly reported, and starvation does not alter the ability of the pituitary-adrenal system to respond to the stimulus provided by whole-body irradiation[1]. This view is supported by the observed decrease of hexokinase activity in rat's tissues following 600 r. of whole-body X-irradiation[2]. The observed sex difference is more difficult to explain. It is possible that this is connected with the known protein anabolic effect of androgens, and so in males these would be more antagonistic to glucocorticoids.

V. Stanković
N. Sestan

Biological Department,
Institut Ruder Bošković,
Zagreb, Yugoslavia.

Aug. 21.

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Hormone Effects on Early Distribution and Disappearance from the Blood of Promethium-147 in Rats

Growth hormone, as well as cortisone, has been shown to alter metabolic balances and tissue distribution of potassium and sodium[1]. With injected calcium-45, growth hormone restored the diminished uptake by bone observed in hypophysectomized rats, but in normal rats it had no effect on uptake of calcium-45[2]. The present work with normal rats demonstrates effects of growth hormone and cortisone on early uptake by tissue and on disappearance from the blood with time of the lanthanide fission metal promethium-147.

Thirty-one young adult female Wister rats (200 ± 25 gm. weight) were bilaterally adrenalectomized and maintained on 2 per cent saline, and/or treated with cortisone (dosage: 45 mgm./kgm. body weight) or growth hormone (dosage: 8 mgm./kgm. body weight), and intravenously injected with 10 μc. promethium-147 (as chloride) in 0·25 ml. of dilute citrate solution, *p*H 2, according to the

Table 1. SCHEDULE OF PRETREATMENTS

No. of animals	Pretreatment and Pm-147	Time interval between : Pm-147 and slaughter (min.)
5	Untreated	10
3	Adrenalectomy (21 days)	10
3	Adrenalectomy (21 days) : cortisone (20 min.)	10
5	Untreated	60
5	Cortisone (20 min.)	60
5	Adrenalectomy (29 days)	60
5	Growth hormone (2, 18, and 24 hours)	60

experimental plan shown in Table 1. Eleven of the animals were killed 10 min. after injection of promethium-147, and radioisotope concentrations in liver, kidney, spleen, and femur were measured. From the remaining 20 animals tail-blood samples were taken under light ether anæsthesia at serial intervals up to one hour after injection of promethium-147, when these animals were killed and their tissues assayed for radioactivity content. Aliquots of terminal blood plasma samples from these animals were treated with four volumes of cold 80 per cent ethyl alcohol, and the concentrations of promethium-147 in the resulting precipitate and supernates were measured. Following correction for self-absorption, the concentrations of radioisotope in the blood and tissue samples were compared to those of 'standards' prepared from aliquots of the original injection solution.

The promethium-147 blood data were programmed for each animal on an *IBM* 650 computor to estimate by a least squares method changes of concentration with time. The four groups of animals were examined statistically for common slope and/or intercept within each group, and then the groups were compared. The parametric estimations are shown in Table 2. Except for the adrenalectomized group, which can be represented by a common intercept of 5·91, intercepts within each group were significantly different at the 5 per cent level. Each representative slope varied randomly about its average, with definite statistical similarities between the control and cortisone group slopes (combined average : $-1{\cdot}01 \pm 0{\cdot}10$), and the slopes of the adrenalectomized animals and those treated with growth hormone (combined average : $-0{\cdot}68 \pm 0{\cdot}12$). This value was about 30 per cent less than the average of the combined control and cortisone groups. Observed differences in rates of disappearance from blood were possibly associated with actions of the treatments on blood constituents which might alter plasma partition and tissue distribution of promethium-147. In plasma the alcoholic precipitation method employed can only approximately indicate association of promethium-147 with protein. The results of this precipitation procedure, shown in Table 3, demonstrate statistically significant differences between the values for the control group and all treatment groups for both total concentration and 'non-protein bound' promethium-147. Whether these differences, in turn, may have been reflected in differences in tissue concentrations between the treatment groups shown in Table 4 is not known. In the control group there was a marked accumulation of promethium-147 in liver, and to a lesser extent, in femur. The concentrations in spleen and kidney differed between the two time periods without a definite statistical upward trend. Contrasted to the control group, all treatments increased concentrations in the spleen and decreased concentrations in the femur of promethium-147. Both adrenalectomy and growth-hormone treatment were associated with large decreases in concentration in the liver, and concentration in the kidney was reduced in the adrenalectomy group. The overall greater similarities between these two groups as contrasted to the effects of cortisone treatment suggest a positive effect, possibly related to a relative excess of growth hormone in the animals. On the other hand, the comparative lack of effect of cortisone treatment is in some accord with the relative briefness of the interval between treatment and injection of promethium-147.

In general, the actions of the hormones in decreasing concentrations of promethium-147 in either liver or femur of normal animals indicate a possible means of evaluation of the role of promethium. By extension to other radioactive fission products, similar studies might also provide insight into means of altering their potential toxicity hazards to animals.

Table 2. LOGARITHMIC VALUES OF PARAMETERS OF BIOLOGICAL DISAPPEARANCE OF PROMETHIUM-147 FROM BLOOD*

Group	Animal No.	Ln intercept	Slope	Average slope	Combined slope
Controls	1	5·60	−0·66		
	2	6·23	−1·14		
	3	6·34	−0·96		
	4	5·80	−0·83		
	5	6·99	−1·25		
				$-0{\cdot}97 \pm 0{\cdot}14$	Controls + cortisone $-1{\cdot}01 \pm 0{\cdot}10$
Cortisone	6	5·99	−0·99		
	7	6·70	−1·03		
	8	6·62	−1·10		
	9	6·93	−1·28		
	10	5·74	−0·78		
				$-1{\cdot}05 \pm 0{\cdot}15$	
Adrenalectomy	11	6·19	−0·77		
	12	5·98	−0·70		
	13	5·78	−0·53		
	14 (outlier)	—	—		Adrenalectomy + growth hormone $-0{\cdot}68 \pm 0{\cdot}12$
	15	5·70	−0·65		
				$-0{\cdot}66 \pm 0{\cdot}17$	
Growth hormone	16	5·37	−0·57		
	17	5·63	−0·55		
	18	5·93	−0·64		
	19	5·58	−0·75		
	20	6·32	−0·96		
				$-0{\cdot}70 \pm 0{\cdot}18$	

* Values obtained during 60 min. following intravenous injection.

Table 3. CONCENTRATIONS IN PLASMA FRACTIONS*

Group	Whole plasma (per cent/ml.)	Protein ppt (per cent/gm.)	Supernate (per cent/ml.)
Controls	$0{\cdot}26 \pm 0{\cdot}04$	$0{\cdot}31 \pm 0{\cdot}09$	$0{\cdot}007 \pm 0{\cdot}004$
Cortisone	$0{\cdot}14 \pm 0{\cdot}03$†	$0{\cdot}13 \pm 0{\cdot}03$†	$0{\cdot}061 \pm 0{\cdot}002$†
Adrenalectomy	$0{\cdot}19 \pm 0{\cdot}02$**	$0{\cdot}27 \pm 0{\cdot}05$	$0{\cdot}089 \pm 0{\cdot}034$†
Growth Hormone	$0{\cdot}20 \pm 0{\cdot}01$**	$0{\cdot}23 \pm 0{\cdot}04$	$0{\cdot}066 \pm 0{\cdot}009$†

* Mean percent of administered dose ±standard deviation.
† Significant difference from controls at 1 per cent level.
** Significant difference from controls at 5 per cent level.

Table 4. DISTRIBUTION (PER CENT/GM. WET WEIGHT) OF PROMETHIUM-147 10 AND 60 MIN. AFTER INTRAVENOUS INJECTION*

Tissue	Liver		Spleen		Kidney		Femur	
Time (min.)	10	60	10	60	10	60	10	60
Controls	$2{\cdot}63 \pm 0{\cdot}64$	$5{\cdot}32 \pm 0{\cdot}51$	$0{\cdot}24 \pm 0{\cdot}04$	$0{\cdot}09 \pm 0{\cdot}02$	$0{\cdot}88 \pm 0{\cdot}35$	$1{\cdot}51 \pm 0{\cdot}11$	$0{\cdot}10 \pm 0{\cdot}08$	$1{\cdot}28 \pm 0{\cdot}05$
Cortisone		$4{\cdot}52 \pm 0{\cdot}33$		$0{\cdot}32 \pm 0{\cdot}02$†		$1{\cdot}21 \pm 0{\cdot}26$		$1{\cdot}01 \pm 0{\cdot}08$†
Adrenalectomy	$2{\cdot}44 \pm 0{\cdot}97$	$2{\cdot}50 \pm 0{\cdot}19$†	$0{\cdot}92 \pm 0{\cdot}007$	$0{\cdot}60 \pm 0{\cdot}10$†	$1{\cdot}55 \pm 0{\cdot}79$	$0{\cdot}68 \pm 0{\cdot}17$†	$0{\cdot}38 \pm 0{\cdot}11$†	$0{\cdot}63 \pm 0{\cdot}07$†
Adrenalectomy + cortisone	$2{\cdot}29 \pm 0{\cdot}49$		$0{\cdot}15 \pm 0{\cdot}04$		$0{\cdot}79 \pm 0{\cdot}73$		$0{\cdot}20 \pm 0{\cdot}05$	
Growth hormone		$3{\cdot}07 \pm 0{\cdot}20$		$0{\cdot}68 \pm 0{\cdot}18$†		$1{\cdot}13 \pm 0{\cdot}14$		$0{\cdot}55 \pm 0{\cdot}06$†

* Mean per cent of administered dose ±standard deviation.
† Significant difference from controls at same time period at 1 per cent level.

BERGENE KAWIN*
Agricultural Chemistry Department,
Michigan State University,
E. Lansing, Michigan.
Oct. 15.

* Present address : Bioscience Branch, Boeing Airplane Company, Seattle 24, Washington.

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Fate of the Highly Polymerized Spleen Deoxyribonucleic Acid labelled with Phosphorus-32 Injected Intraperitoneally into Rats

It has been shown in this laboratory that preparations of highly polymerized rat spleen and liver deoxyribonucleic and ribonucleic acids produce a recovery effect on irradiated rats[1,2,3]. Furthermore, in the same laboratory it was demonstrated that spleen nucleic acids administered to the irradiated rats have a restorative effect on hæmolysin production[4], which regularly becomes reduced after the irradiation.

Therefore, it was of interest to study the mechanism of the protection accomplished by this material, also, to find eventually more favourable conditions for the recovery and to explain the mode of action of the protective agent. First of all we studied the state of polymerization, in which the intraperitoneally injected spleen deoxyribonucleic reaches the organs, that is, the degree of degradation, further the rate of resorption into the blood circulation and the rate of its utilization by the cells of different organs (liver, spleen and testis).

Spleen deoxyribonucleic acid labelled with phosphorus-32 was injected intraperitoneally under experimental conditions simulating those in which recovery was observed[2,3]. Animals of the same age and body-weights were used for the experiments. Irradiation conditions were identical with those already described in recovery studies[2,3].

For the preparation of labelled deoxyribonucleic acid the donor rats were injected subcutaneously four times at 12-hr. intervals with 50 μc. of carrier free phosphorus-32 ($NaH_2{}^{32}PO_4$, Amersham) and deoxyribonucleic acid isolated by a method previously described[1,2]. The characteristics of the preparation were as follows: spec. activity 3,700 c.p.m./mgm. deoxyribonucleic acid; phosphorus content 8·2 per cent; protein contamination 0·7 per cent; ribonucleic acid contamination 2·5 per cent; OD_{260} per γ phosphorus = 0·200.

The test for the stability to heat according to Zamenhoff[5] showed a 1 per cent decrease of specific viscosity after heating for 1 hr. at 76°C., indicating that deoxyribonucleic acid presumably was not denaturated during the isolation.

Each of the recipient normal and irradiated animals was injected intraperitoneally with 2·8 mgm. of labelled deoxyribonucleic acid (10,600 c.p.m. per animal). This application was made immediately after irradiation. The animals were killed at different time-intervals after the injection. The following organs were used for biochemical analysis and for radioactivity measurements: spleen, liver and testis, plus whole citrated blood.

It is assumed that deoxyribonucleic acid if not incorporated in cellular deoxyribonucleic acid-protein, might be soluble in 0·14 *M* sodium chloride solution[6]. Therefore we made the extractions with 0·14 *M* sodium chloride of spleen, liver and testis and those extracts were fractionated by acidification with perchloric acid[6] in acid-soluble and acid-insoluble fractions. The radioactivity was measured in the whole extract and in the acid-soluble fraction. The differences in radioactivity could be attributed to the larger fragments of deoxyribonucleic acid.

The whole blood was analysed for radioactivity and fractionated in acid-soluble and acid-insoluble fractions. The radioactivity was measured in both fractions.

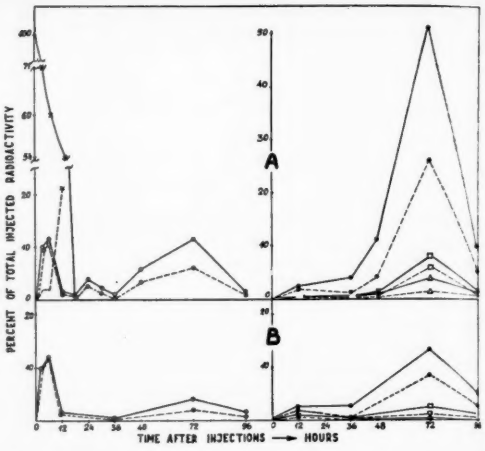

Fig. 1. Percentage of total injected radioactivity found in different intervals of time in blood, peritoneum and in 0·14 *M* sodium chloride extracts of spleen, liver and testis. *A*, control animals, *B*, irradiated animals
○, blood; ×, peritoneum; ●, liver; △, spleen; □, testis; — — —, acid-soluble fractions

The peritoneal cavity was washed out with a known volume of saline before killing and the radioactivity measured in the whole washing and in the acid-soluble fraction of it.

In Fig. 1*a* the total amount of radioactivity of blood, peritoneum and of the 0·14 *M* sodium chloride extract from the organs mentioned above (expressed as per cent of total injected radioactivity) is plotted against the time after the injection in the control animals, and in Fig. 1*b* into the irradiated ones.

During the first 12 hr. about 10 per cent of the injected radioactivity could be found in the total blood circulation. The localization of the marker in the organs mentioned above is minimal. If there is some, all the radioactivity of the 0·14 *M* sodium chloride extract can be found in the acid-soluble fraction. Within the same time-interval about 50 per cent of the injected radioactivity disappeared from the peritoneum.

Within the time-interval of 12–36 hr. after the injection no marked changes in the radioactivity were found in the blood, nor in the 0·14 *M* sodium chloride extracts from the organs except in the liver. Here a slight increase in the total radioactivity is evident followed with a drop of the activity in the acid soluble fraction of the 0·14 *M* sodium chloride extract. During this period no essential differences between the control and irradiated rats were observed. In peritoneum washings 18 hr. after injection no detectable amounts of radioactivity could be detected.

In the next 36 hr., that is, from 36 to 72 hr., a second peak in radioactivity in the circulating blood is observed. Within the same time-period in spleen, liver and testis extracts of the controls show a significant increase of radioactivity with a maximal value in the 72nd hour. At this point 50 per cent of the total injected radioactivity was found in the liver, 4 per cent in the spleen and 8 per cent in the testis of the non-irradiated ones. In the irradiated animals much lower values are observed: in the liver 13 per cent, in the spleen insignificant amounts and in the testis about 3 per cent of the total injected radioactivity. The distribution of radioactivity between acid-soluble and acid-insoluble fractions

was as follows : liver 1:1, spleen 2:3, testis 3:1 in the controls, and liver 2:1 and testis 3:1 in the irradiated ones. The radioactivity of the inorganic phosphorus determined in the acid-soluble fraction was never more than 20 per cent of the radioactivity found in the soluble fraction.

At those time-intervals the deoxyribonucleic acid from spleen, liver and testis was isolated by the method of Schmidt and Tannhauser[7] and the specific activity determined and expressed in c.p.m. per mgm. of deoxyribonucleic acid (calculated from phosphorus content). Only deoxyribonucleic acid from spleen of control animals shows a significant specific activity, but not before the third day after the injection. The whole deoxyribonucleic acid from the spleen contains at this time-interval only 3 per cent of the injected radioactivity.

These very preliminary results lead us to the following conclusions. The injected highly polymerized spleen deoxyribonucleic acid labelled with phosphorus-32 seems to be at least 50 per cent degraded to tetranucleotides and smaller fractions. It is very likely that this degradation takes place in the peritoneum. The fact that 30–40 per cent of the labelled deoxyribonucleic acid is found as fragments precipitable with perchloric acid or trichloracetic acid in blood and organ extracts and the fact that only deoxyribonucleic acid from spleen was labelled for a relatively short time-period could suggest that those larger fragments were used for the synthesis of spleen deoxyribonucleic acid. This might also suggest an organ-specific localization of larger fragments of labelled deoxyribonucleic acid. Also, if one compares the incorporation of labelled inorganic phosphate to spleen deoxyribonucleic acid and the intraperitoneally injected spleen labelled acid, there is a 300 times greater efficiency in the latter.

It is of interest to mention that highly polymerized liver labelled deoxyribonucleic acid injected intraperitoneally under the same conditions was degraded into smaller fragments as observed in our laboratory[8].

However, more information is needed to understand better this phenomenon. Experiments in this direction are in progress and will be published elsewhere.

The authors wish to thank Dr. D. Kanazir for his continuous interest and stimulating discussion during the course of the work.

Tamara A. Hudnik-Plevnik
Vladimir R. Glišin
Marta M. Simić

'Boris Kidrich' Laboratory of Radiobiology,
Institute of Nuclear Sciences,
P.B. 522, Belgrade.

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BIOLOGY

A Nucleus of Nerve Cells in the Ferret Pituitary Gland

The neural process of the pituitary gland is a derivative of the neural tube, and in adult animals remains structurally continuous with the hypothalamus by means of a stalk consisting of nerve fibres. Until recently it was considered to be a true endocrine gland ; but today it is widely held that the process serves as an organ for the storage and release of hormones elaborated by the neurones of certain hypothalamic nuclei[1].

Structurally the process consists chiefly of nerve fibres containing neurosecretory material, and cells of unknown function called 'pituicytes'. Scattered nerve cells have also been described in the neural process of some forms, including the dog[2] and human[3].

The neural process of the ferret consists of an upper central zone which is directly continuous with the stalk, and resembles it structurally ; and a more vascular peripheral zone which contains a high concentration of neurosecretory material. Occasional scattered nerve cells are found throughout the central zone. In the junctional region where the stalk becomes continuous with the main neural process these cells are aggregated to form a distinct nucleus, which measures approximately 0·5 mm. in its greatest extent. The cells are typical small and medium-sized neurones, whose oval nuclei contain prominent nucleoli, and whose cytoplasm shows granules of Nissl substance. It has not been possible to demonstrate neurosecretory material within the cytoplasm of these cells.

The significance of this collection of nerve cells, the occurrence of which has to the best of my knowledge not been previously described, is problematical. The neurones may represent a displaced hypothalamic nucleus, and receive direct fibres from other parts of the central nervous system ; or alternatively they may constitute a relay for fibres, not necessarily neurosecretory in nature, passing from the hypothalamus to the neural process. In either case they would be likely, through the influence of these axons, to play a part in the control exerted by the central nervous system over the neurohypophysis, and possibly over the whole pituitary gland. A third possibility is that these neurones give rise to centripetal fibres, and are concerned in the mediation of a 'feedback' effect, through which the neural process could influence the central nervous system.

R. L. Holmes

Department of Anatomy,
University of Birmingham.

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GENETICS AND CYTOLOGY

Interspecific Hybrids of *Lycopersicum*

The production of fertile hybrids between members of the species *Lycopersicum esculentum* and *L. peruvianum* var. *dentatum* has been achieved at the Plant Breeding Laboratory, Melbourne, Victoria, by the adoption of a technique involving the reciprocal grafting of parent plants prior to hybridization. Eight self-fertile interspecific hybrids, produced by this method during the period 1955–58, have been observed and selected from F_1 to F_4.

F_1 hybrids and selected segregates from later generations have been backcrossed to *L. esculentum*. Resistance to the tomato spotted wilt virus and to *Fusarium oxysporium* var. *lycopersici* has been transmitted to *esculentum* type segregates. There is no evidence of linkage of the genes determining size of fruit and those for disease resistance.

The parent material was cleft-grafted in the early stages of growth, the scion being at first true leaf

emergence, the stock approximately seven days older. Interspecific grafting was found to be more difficult than grafting within the species, but the *L. peruvianum* (scion)—*L. esculentum* (stock) graft was easier to achieve than its reciprocal. Approach grafting, involving plants in a later stage of development, was relatively easy to achieve, but crossings utilizing material of this nature failed to produce viable seed.

Hybridization under glass-house conditions was successful only when *L. esculentum* was used as the maternal parent. Seed development in the hybrid fruit was superior to that observed in the progeny of ungrafted matings. Some evidence of embryo breakdown was apparent in individual seeds.

The F_1 hybrid is morphologically intermediate to the parent species, but variation between individual hybrids arising from different matings is apparent. The hybrid is typically vigorous, semi-fertile to fertile, and exhibits some irregularity in meiotic behaviour. Seed setting is good, but seed viability and seedling survival-rate is generally low. The fertility of the hybrid and the viability of the seed produced increase with the age of the plant.

Segregation in the F_2 and subsequent generations is irregular, with the majority of the individuals resembling the *L. peruvianum* parent type. Segregation occurs in respect of such characters as vegetative type, growth habit, maturity, fruit size, shape and colour and resistance to disease. Dwarf-type plants, many of which are sterile, occur, and the F_2 population presents an entire range of fertility. Fertile *esculentum* type plants represent approximately one per cent of the total. Meiotic behaviour in F_2 varies appreciably with the individual, but approaches normality in the more fertile segregates. Variability in F_3 and F_4 follows the same general pattern as in F_2, but all ratios are upset by the sterility factor.

A number of *esculentum* type families carrying resistance to the tomato spotted wilt virus and/or *Fusarium* wilt have been isolated and are undergoing further field testing.

The F_1 hybrid, and selected segregates from later generations, backcross readily with *L. esculentum*, when the latter is employed as the pollen parent, and *esculentum* characters are rapidly recoverable.

A number of disease-resistant backcross strains have been developed. Crossing of the hybrid to *L. peruvianum* does not produce viable seed.

The first self-fertile hybrid was produced in 1955. Since that time seven similar hybrids have been obtained from further matings. The original F_1 plants have been maintained by vegetative propagation. The material is tested for disease reaction by artificial inoculation and field-infection.

The technique offers distinct possibilities for the breeding of disease-resistant tomato varieties by utilizing sources of resistance that have not hitherto been available.

Helgi Nirk

Victoria Department of Agriculture,
Melbourne, C.2.

Pachytene in *Puccinia kraussiana* Cooke, on *Smilax kraussiana*

Puccinia kraussiana Cooke is a rust with large teleutospores which will germinate without a resting period. This, together with the fact that the nuclei are large and stain well in comparison with those of most fungi, make this a very favourable object for the study of meiosis as it occurs in fungi, comparable with the rust *Coleosporium vernonae* so fully described by Olive[1].

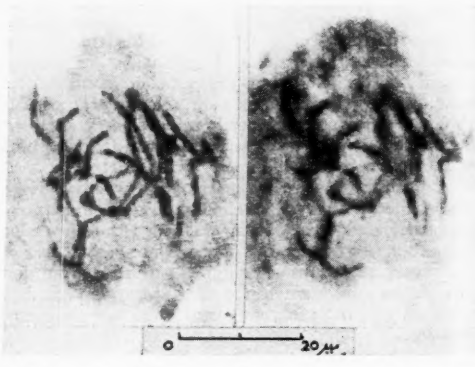
Surprisingly good pachytene preparations were obtained from material which had been fixed over night or longer in acetic-alcohol and squashed in aceto-carmine.

Figs. 1 and 2 are photomicrographs of the same nucleus at different focal levels and Fig. 3 is an interpretation of them.

The chromosome number is 20, 21 or 22, according to whether the chromosomes marked *a* and *a'* represent one or two chromosomes. The haploid chromosome numbers of certain *Puccinia* species, determined from mitosis in the germinating basidiospores, have been reported by McGinnis[2] as being 4 in homothallic species, and 3 and 6 in heterothallic species. If *Puccinia kraussiana* belongs to either of these series, it is evidently highly polyploid.

The nucleolus might be interpreted as being interstitially attached to one pair of chromosomes, but in other nuclei it is terminally attached, so it is believed that in this nucleus two pairs of chromosomes are terminally attached to the nucleolus.

One pair of chromosomes appears to have an inversion loop. Fragments and bridges, such as would result from crossing-over in inverted regions, have been observed quite frequently at later stages.



Figs. 1 and 2. Photomicrographs of one pachytene nucleus at two foci

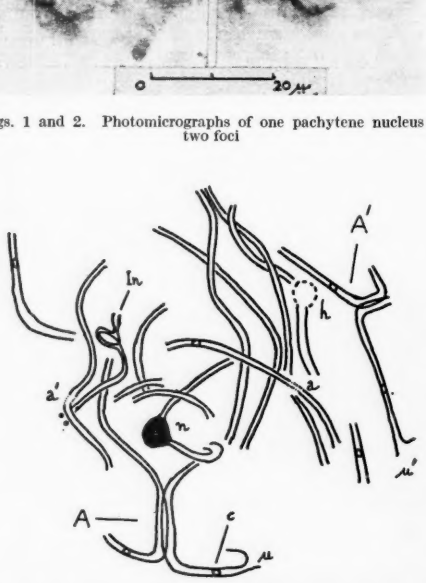


Fig. 3. Interpretation.
a, *a'*, ends of two chromosome pairs or constriction in one pair; *n*, nucleolus; *c*, centromere; *h*, possible heterochromatin; *in*, inversion; *A*, *A'*, associations of four chromosomes

The associations of four A and A' are also of interest. As shown in Fig. 2, at u and u' two of the paired arms in each configuration have comparable unpaired ends. This, together with the fact that other pachytene nuclei have been obtained without such unpaired ends and without any association of four, indicates that the chromosomes involved in A and A' may be inter-related.

A fuller account of meiosis and basidiospore production and germination in this fungus is in the course of preparation.

I am indebted to Dr. F. C. Deighton for identifying the fungus and to Mr. C. N. Williams for the illustrations.

EVA SANSOME

University College,
Ibadan, Nigeria.

[1] Olive, L. S., *Amer. J. Bot.*, **36**, 41 (1949).
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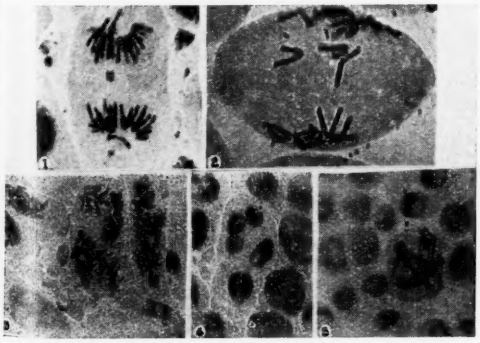
Chromosome Breakage with Plant Pigments

LATELY, the property of the bacterial products in causing chromosome breakage has been worked out by certain authors[1–5]. Such results have been taken to indicate the mutagenic property of the soil accounting for spontaneous mutation and chromosome breakage. Several algal groups, too, form an important constituent of the soil, and it was desired to find out how far their decomposition products contribute to the mutagenic property of the substratum.

Different genera of the algæ belonging to the different groups occurring in moist area in the soil were chosen, namely, species of *Tribonema* of Xanthophyceae; *Spirogyra*, *Ulothrix* and *Formidium* of Chlorophyceae and *Oscillatoria*, *Lyngbya* and *Microcoleus* of Cyanophyceae. Pigments of cyanophycean species were extracted in water and other groups in alcohol. Chlorophyll pigments were also extracted from the leaves of *Cestrum nocturnum*, a solanaceous plant, for checking the results obtained from lower plants with chlorophyll. *Allium* test was performed with different dilutions of stock solutions and recovery tests, too, in Knop's medium after treatment was carried out. Observations were made following aceto-orcein root tip squash and Feulgen squash techniques. Control experiments were also set up treating the roots in solvents alone as well as in Knop's medium, and no cytological effects noted with the extracts were observed, indicating the reliability of the results.



Figs. 1–5. Showing the effect of chlorophycean extracts on root tip cells of *Allium cepa*, namely, anaphasic fragment, somatic reduction, polyploidy, multinucleate condition and multipolar arrangement respectively (Figs. 1 and 2 × *c.* 500; Figs. 3, 4 and 5, × *c.* 250)

Distinct chromosome breaks were observed in all the sets of experiments (Fig. 1) though the frequency of breakage was found to be very high (60–65 per cent in dividing cells) after treatment with chlorophycean extracts for 6–24 hr. followed by recovery in Knop's medium. With prolonged keeping in Knop's medium the frequency of fragments gradually increased reaching a maximum (90–95 per cent in dividing cells) in 48 hr. In prolonged treatments polyploidy was noticed only in a few cases. In addition to polyploidy, multipolar conditions within a cell, somatic reduction as well as multinucleate cells were observed, specially in new roots coming out in Knop's medium (Figs. 2–5). Though with all the groups profuse fragments could be recorded after transference in Knop's medium, with chlorophycean extracts even before transference chromosome breaks were found to be profuse. The delayed breakage with other groups of algæ may indicate the latent nature of the effect.

The similarity in behaviour between chlorophycean extract and pigment extracts of higher plants indicates possibly that chlorophyll is the main causal factor in chromosome breakage. The demonstration of this property of inducing chromosome breakage by plant pigments so far unexplored has far-reaching significance and indicates that the latter contribute to a large extent to the mutagenicity of the soil, accounting for the spontaneous mutation. Detailed results are being published elsewhere.

ARUN KUMAR SHARMA
ARATI GUPTA

Cytogenetics Laboratory,
Botany Department,
Calcutta University,
Calcutta, 19.

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BACTERIOLOGY

Rate of Appearance of Mutants with Respiration-deficiency in *Staphylococci*

MUTANTS of *Staphylococcus aureus* with impaired respiration were originally obtained under the action of ultra-violet radiation[1], and as they differed in a number of important characters from the parent strain it was of interest to develop a simple method for their detection and to measure the frequency of appearance of these mutants in the parent culture under various conditions.

The experiments were carried out with *Staphylococcus aureus*, strain 209. Under the usual conditions of observation, it is impossible to detect mutants with impaired respiration in this culture, because: (1) the frequency of their appearance is very low and they grow slowly; in dense cultures the mutants are entirely overgrown by the more rapidly growing parent cells, while in diluted cultures on the surface of nutrient agar the chances of their detection are negligible; (2) on the surface of nutrient agar containing glucose, parent cells produce acid, whereas mutant cells do not; this production of acid selectively inhibits the growth of mutant *Staphylococci* with impaired respiration, as can be observed in experiments by inoculating artificial mixtures of parents and mutant cells on the surface of nutrient agar containing glucose

Table 1

Source of deoxyribonucleic acid	Frequency of mutants per 10^8 cells	
	No deoxyribonucleic acid	With deoxyribonucleic acid
Mutant *uv*-2	1·04	1·08
Mutant *uv*-21	1·07	0·94

To detect mutants with impaired respiration in the parent culture of *Staphylococci*, the conditions of growth should be highly selective for mutants and unfavourable for parents. This condition was obtained by incorporating 'Albomycin' in the nutrient media used for the experiments. 'Albomycin' specifically inhibits the growth of parent cells of *Staphylococci* but does not interfere with the growth of the respiratory-deficient mutants[1]. The following medium was found to be very favourable for the detection of mutants with impaired respiration in *Staphylococci*: tryptone, 0·2 per cent; sodium chloride, 0·5 per cent; sodium acetate, 0·5 per cent; corn steep liquor, 0·1 per cent; 'Albomycin', 50 units/ml.; agar, 3 per cent; *p*H 7·0.

Suspensions of parent *Staphylococci* strain 209 containing 10^8 cells per 0·1 ml. were spread in Petri dishes on the surface of this nutrient agar, and after seven days incubation at 37°C. the colonies of mutants with impaired respiration were recognized by their orange, red or rose colour. These mutants were isolated, and their respiration-deficiency proved by the Warburg technique; oxygen consumption in glucose phosphate buffer solution was measured. It was observed that in strain 209 these mutants appeared regularly with the frequency of 1·04–1·07 per 10^8 cells.

An attempt was also made to increase the frequency of mutants with impaired respiration by incubating parent *Staphylococci* in the nutrient medium containing deoxyribonucleic acid extracted from mutants. Two strains of respiratory-deficient mutants were used for this purpose, *uv*-2 and *uv*-21. Highly polymerized deoxyribonucleic acid was isolated from the cells of mutants by the method of Chargaff and Zamenhof[2], and freed from protein by the use of the phenol technique developed by Kirby[3]. In the light of observations published by Imshenetsky *et al.*[4], the preparations of deoxyribonucleic acid were used immediately after their isolation for experiments on transmittance of respiration deficiency. No increase in the frequency of appearance of mutants with impaired respiration was induced in the parent strain of *Staphylococci* by deoxyribonucleic acid from mutants, as is clear from the results in Table 1.

G. F. Gause
G. V. Kochetkova
N. A. Sorbaeva

Institute of Antibiotics,
Academy of Medical Sciences,
Moscow, U.S.S.R.
Oct. 13.

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Mutation in the Type-determining Phages of *Salmonella typhi*

The appearance of a communication on clear-plaque mutation in the type-determining phages of *Salmonella typhi*[1] prompts me to publish a brief account of observations which commenced in 1953 and on which work is still in progress. With the exception of phage *d*1, clear-plaque mutants of all the phages described by Read and Ferguson were isolated in this Laboratory some years ago.

The characterization of the original temperate type-determining phages[2,3] had shown that each was capable of yielding a number of different *Vi*-types of *S. typhi*, the identity of which depended on that of the non-lysogenic precursor strains chosen for lysogenization. Moreover, the phages isolated from certain distinct, naturally occurring *Vi*-types proved to be indistinguishable from each other. For these reasons, we pointed out[4] that it was unjustifiable to give the phage isolated from each lysogenically determined *Vi*-type a separate designation on the grounds that the type carrying it was specific. Thus, types *D*6, *C*2 and *E*9 carry phage *d*6, their structural formulæ being *A*(*d*6), *C*1(*d*6) and *E*1(*d*6) respectively. Similarly, types *F*2, *E*7 and 29 carry phage *f*2 and are structurally designated as *E*1(*f*2) and *A*(*f*2). In the same way, determining phage 26′ controls the specificity of *Vi*-types 26, = *A*(26′); *E*8, = *E*1(26′), formerly designated type 31; and *C*8, = *C*1(26′).

The 'specific' type-determining phages defined hitherto are shown in Table 1.

Table 1. Type-Determining Phages of *Salmonella typhi*

Vi-types of *Salmonella typhi*	Determining phage carried
*C*9	*c*9
*D*1	*d*1
*D*8	*d*8
*D*9, *D*10	*d*9
*D*6, *C*2, *E*9	*d*6
*F*2, *C*3, *E*7, 29	*f*2, or 30′*
*J*2	*j*2
T	*t*
25	25′
26, *E*8, *C*8	26′

* Phages *f*2 and 30′ have identical type-determining properties.

We have isolated clear-plaque mutants from all these phages with the exception of *d*1, *d*8 and *d*9. A study of these mutants has disclosed a number of interesting properties. For example, when a culture of *Vi*-type *A* of *S. typhi* is lysed on a solid medium by phages *f*2*v* or *d*6*v*, the clear-plaque mutants of phages *f*2 and *d*6 respectively, the great majority of surviving colonies of the bacterium consist of cells that are *Vi*-negative. These bacteria are non-lysogenic and, somewhat surprisingly, are sensitive to the phages responsible for their selection. Whether they represent true mutation to the *Vi*-negative state or result from the suppression of synthesis of *Vi* antigen in genotypically *Vi*-positive organisms it is at present impossible to say. The *Vi*-negative state is maintained for a number of generations, but clonal reversion to the *Vi*-positive state occurs, so that platings of the *Vi*-negative lines soon begin to show the presence of the characteristically opaque and iridescent *Vi*-positive colonies.

The clear-plaque mutant of phage 25′, which we have designated 25′*c*, is not a virulent phage but lysogenizes host cells with a much lower frequency than does its turbid-plaque parent. When *Vi*-type *A* is attacked by this phage, a high proportion of the resistant clones differ from each other in their lysogenic properties. Such clones reveal their carriage of prophage 25′*c* by the fact that they belong to *Vi*-type 25. When they are examined for liberation of mature phage, however, a number of different varieties of release are found. Some usually liberate no mature phage whatever, although on rare occasions a few free particles may be detected. Other lines constantly yield

a few free phage particles. Others liberate free phage in abundance during logarithmic growth only. In yet others, the optimal period for release of phage seems to be after logarithmic growth of the bacterial host has ceased. A fifth type is doubly lysogenic for both the clear-plaque mutant and a turbid-plaque reversion, the dynamics of release of the two plaque types appearing to differ.

The wide range of types of lysogenicity in this system might result from heterogeneity in the host cell or in the lysogenizing phage, or from a random probability depending on the site or mode of integration of the prophage into the bacterial chromosome. Some purified clones lysogenized with 25*c* show variation in the dynamics of release of free phage for a short time after isolation, which suggests that the phage is sometimes present as a non-integrated cytoplasmic particle, or that a stable form of prophage integration has not yet been reached which would result in uniform characteristics of spontaneous induction.

The phenomena described above are constant features of lines that have been purified by repeated single-colony isolations over a period of more than four years. They can thus be regarded as stable characters of the clones concerned. Most of these lines lose their prophage after storage at room temperature for about 12 months and simultaneously revert to *Vi*-type *A*.

These observations will be reported in full at a later date.

E. S. Anderson

Central Enteric Reference Laboratory
and Bureau,
Public Health Laboratory Service,
(Medical Research Council),
Colindale Avenue,
London, N.W.9.

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PSYCHOLOGY

Subjective Light Pattern Spectroscopy in the Encephalographic Frequency Range

Allessandro Volta's famous experiment in 1800 when he stimulated the nerve of the leg of a frog by a battery of a few volts is well known. In his collected works[1], however, much more attention is given to another experiment, when he applied two electrodes to different parts of his face and experienced, with eyes closed, a brilliant light and sometimes a bright circle while closing or opening the circuit including his little battery.

Some years later, 1819, Purkinje confirmed Volta's experiment and found quite a number of differently shaped subjective abstract patterns, excitable optically, mechanically or electrically[2]. Looking closer into his reports one finds that he obtained his best results not by simply opening or closing the circuit but by using a metal chain to interrupt the battery current. Therefore, he must have used a rather irregular but wide electric (low-frequency) pulse spectrum. Penfield and Rasmussen obtained not many years ago similar patterns during brain surgery by direct electric stimulation of the visual cortex with a fixed pulse-frequency of 60 c./s. (ref. 3), and since then the electric conditions for excitation of Purkinje patterns have been investigated by one of us (M.K.)[4]. It has been found that (besides flicker) a whole 'spectrum' of subjective abstract light patterns can be excited in the brain by using temporal electrodes and pulses of a few volts within the encephalographic frequency-range.

The 20 subjects tested in this earlier work belonged to various professional and age groups. In the present communication results are described with an additional 24 subjects belonging to more typical groups (clinical patients and technical students). For each subject, the pulse voltage, current, frequency, repetition ratio and band-width (if possible) for the excitation of a pattern were noted. For the first group, electroencephalographic records were available. In both groups subjects were requested to sketch the patterns observed while the experiments were going on. Subjects in group 1 had no knowledge of the purpose of the experiment. Readings of the electric data by the experimenter and the subject's remarks were tape recorded. For details of the experimental method, the battery-driven transistor pulse generator and the non-electric excitation of subjective patterns, see ref. 4.

Fig. 1 shows 24 pattern spectrograms (17 mental patients, 7 technical students). Reported patterns (copied from original drawings of subjects) are shown at their mean excitation frequency (measurement of band-width, if any, indicated by the sign —). Flicker minima are indicated by the sign =, or by the sign — if band-width was observable. The observations may be summarized as follows:

(1) As found earlier[4], all patterns drawn by the subjects are of an abstract (mostly geometrical) nature.

(2) The band-width of the patterns excited is mostly less than 10 per cent of the mean excitation frequency.

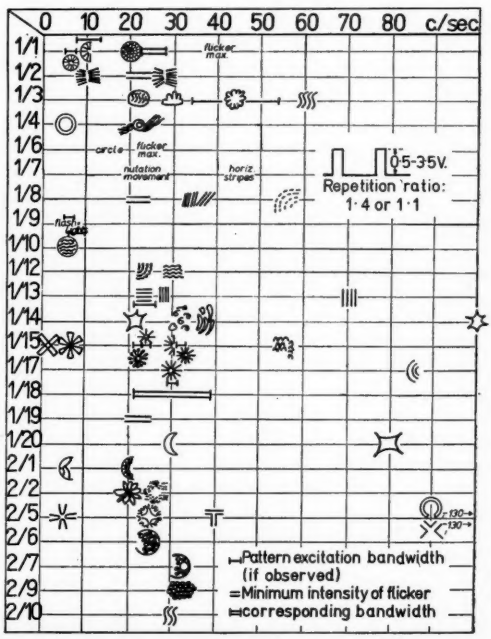

Fig. 1. Spectra of individual pattern mean excitation frequencies and their bandwidth (1/Patients, 2/Students)

(3) The optimum effective excitation pulse voltage varied for different subjects from 0·5 to 3·5 V., the optimum excitation current from 0·1 to 1·4 m.amp.; the corresponding impedance values from 30 to 2·5 k.ohms.

(4) While shapeless flicker covers a large frequency-range, patterns are excitable mostly within the encephalographic frequency-range (5–35 pulses/sec.).

(5) Dark adaptation and closing of eyes facilitate observation of subjective patterns.

(6) Some subjective patterns ma change their shape spontaneously during excitation even if pulse voltage, current and pulse-rate are not varied; others may be found at the same mean excitation frequency weeks after the first experiment.

(7) The number of subjective patterns excitable in each individual was longer for mental patients than for technical students.

(8) Group 1 of Fig. 1, and another group of similar size, mostly epileptics and patients with abnormally low electroencephalograph frequencies, exhibited pattern excitation frequencies less than 10 pulses/sec.; on the other hand, most patients with beta-electroencephalographic activity showed pattern excitation frequencies greater than 50 pulses/sec. (Because the groups investigated so far are relatively small, this result cannot yet be regarded as definitive.)

(9) The fact that many abstract patterns observed by us (such as stars, wheels, bright dot patterns, etc.) have been described before as a result of mechanical stimulation of the eyeball seems to indicate that the retinal ganglion network is at least contributing to the production of the phenomena observed. On the other hand, since similar patterns were observed by Penfield and Rasmussen, the participation of the visual cortex or of the main visual pathway cannot be excluded.

M. Knoll

Institüt für Technische Elektronik,
Technische Hochschule,
München.

J. Kugler

Universitäts-Nervenklinik,
München.

Aug. 1.

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Effects of Printing Types and Formats on the Comprehension of Scientific Journals

An experiment was carried out at the suggestion of the Cambridge University Printer to determine the relative comprehensibility in scientific papers of four different styles of printing. Conditions I–IV in Table 1 are representative of formats and types which have been found from experience in printing scientific journals at the University Press to be both readable and economical. Specimens are given on the opposite page.

Table 1

Condition	Monotype series No.	Monotype series Name	Letter height (in.) Total	Letter height (in.) x-height	Leading between lines (in.)	Line length (in.)	Columns per page	Mean score for comprehension (per cent)
I	7	Modern Extended No. 1	0·15	0·07	0·03	5·2	1	63
II	101	Imprint	0·15	0·07	0·02	5·0	1	58
III	7	Modern Extended No. 1	0·13	0·05	0·01	2·8	2	56
IV	327	Times New Roman	0·13	0·06	0·01	2·8	2	58

Note: Letter height and leading are conventionally given in points; 1 point = 0·014 in.

Two passages of 1,150 words were written on unfamiliar topics. The layout was that of a scientific paper, but without title, subheadings, summary or tables, etc. Both passages were printed in all four styles. Volunteers read one passage printed in one style, and the other passage printed in another style, according to a balanced statistical design. Four minutes were allowed for reading a passage. Comprehension was then tested at once by 17 questions, each of which could be answered in a few words.

Altogether 275 scientists from the University of Cambridge acted as experimental subjects, including 5 professors and 3 university readers. 55 per cent were less than 30 years old, and 15 per cent more than 40. In order to exclude foreign students with an insufficient grasp of English, a minimum score for comprehension of 25 per cent was required on the first passage read.

The last column of Table 1 shows that condition I was considerably easier to comprehend than any of the other styles tested ($P < 0{\cdot}01$). If anything condition III was a little more difficult to comprehend than either of the remaining two conditions (but $P > 0{\cdot}05$).

The superiority of the larger type and longer line of condition I over condition III which had the same style of type, is in line with the findings of Burt *et al.*[1,2], although their experiment did not give statistically reliable results. The advantage of condition I over condition II must be due very largely to the style of type, since the size was the same, and other differences were small. This is the first time that a statistically reliable difference in the rate of comprehension has been found between two styles of type in general use. It suggests that the methods used previously to measure the rate of comprehension may not have been sufficiently sensitive.

The average scores for comprehension were 61 per cent for the under 30's, 58 per cent for those

We wanted to measure the effectiveness of a training method which American universities use widely for poor readers. The training generally produces a considerable increase in the speed of reading as measured in the reading clinic, and a slight increase in comprehension. Students taking courses in verbal subjects (languages,

Condition I

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Condition II

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This is followed by a test passage, and the remainder of the period is filled with training exercises and discussion.

The sixteen films each project on to a screen one

Condition III

We wanted to measure the effectiveness of a training method which American universities use widely for poor readers. The training generally produces a considerable increase in the speed of reading as measured

is followed by a test passage, and the remainder of the period is filled with training exercises and discussion.

The sixteen films each project on to a screen one page of a book at a time. At any moment all the words are

Condition IV

between 30 and 39, and only 53 per cent for the over 40's ($P<0{\cdot}001$). There was also a greater proportion of English-speaking scientists older than 40 than younger than 30 who were excluded from the experiment because they scored less than 25 per cent on their first passage ($P<0{\cdot}05$).

The single-column passages of conditions I and II were read more quickly than the double-column passages of conditions III and IV ($P<0{\cdot}01$). 26 per cent of the volunteers failed to finish reading both passages in the allotted time; their average rate of reading was thus less than 300 words per min. The faster readers tended to score more highly on the tests of comprehension ($r=0{\cdot}38$).

Rate of reading was not related to age, although 74 per cent of those other than 40 wore glasses, as compared with only 37 per cent of those younger than 30. There were no significant differences between scientific departments on any measure.

A fuller description of the experiment is given in a separate report[3], which reviews previous experimental work, and also discusses the limitations and implications of the results for the printing of scientific journals.

I am most grateful to all the scientists who so kindly consented to act as experimental 'guinea pigs'. I am also indebted to Mr. J. G. Dreyfus of the Cambridge University Press for his specialized knowledge, and to Dr. M. Stone for advice on statistics.

E. C. Poulton

Medical Research Council,
Applied Psychology Research Unit,
Cambridge.

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STATISTICS

Heads-Tails Statistics for Two Partially Distinguishable Coins

Two coins are tossed; what is the probability that the outcome will be one head and one tail? The answer to this question for classically distinguishable coins is, of course, one-half. If, on the other hand, the coins are indistinguishable, the answer is usually given as one-third or one for coins which are respectively described by Bose–Einstein or Fermi–Dirac statistics.

The reason why the latter answer is conceptually troublesome is that no continuous transition is usually given from the distinguishable to the indistinguishable case. I shall show here that distinguishability can be defined in a way which makes such a transition possible.

The reason that actual coins are distinguishable is that they differ in respects such as mint marks, scratches, amount of oxidation, etc. More subtly, they are overwhelmingly probable to differ in the exact dynamical state of the electrons and nuclei which they comprise. In other words, coins have a multitude of degrees of freedom other than their 'headness' or 'tailness', and it is this fact which makes them distinguishable in practice; in the language of quantum mechanics, we would say that the 'heads' and 'tails' states are highly degenerate.

On the other hand, it must be assumed that these other degrees of freedom do not interact with the 'headness-tailness'; that is, they do not affect the probability of heads or tails. One can therefore write the state vector of a two-coin system as a product of a 'heads-tails state vector' and a 'distinguishability state vector', the latter describing the various characteristics that might be used to tell the coins apart.

The point of view I am taking is thus that intrinsi-

cally any two coins are indistinguishable; but that each has available a number of distinguishability states, and provided they are not both in the same distinguishability state, we can use the properties of these states to tell them apart.

I assume that we are dealing either with Fermi coins or with Bose coins. Let M be the number of distinguishability states available to one coin; that is, let the 'heads' and 'tails' states be M-fold degenerate. We now define the *indistinguishability parameter* μ by $\mu = \pm 1/M$; the upper sign for Fermi coins, the lower for Bose coins. For the two-coin system, there are M^2 possible distinguishability state vectors, of which $1/2\,(M^2 + M)$ are symmetric and $1/2\,(M^2 - M)$ antisymmetric. In terms of the indistinguiability parameter, the number of symmetric states is $1/2\,M^2\,(1 \pm \mu)$ and the number of antisymmetric states is $1/2\,M^2\,(1 \pm \mu)$, where again the upper and lower signs apply respectively to Fermi and Bose coins.

There are, on the other hand, exactly four heads-tails state vectors, namely:

$$\begin{array}{ll} HH & (+) \\ TT & (+) \\ HT + TH & (+)^* \\ HT - TH & (-)^* \end{array}$$

The signs in parentheses indicate the symmetry, and the starred vectors are the ones containing one head and one tail.

Since the total state vector must be symmetric or antisymmetric for Bose or Fermi coins respectively, we find that the total number of possible state vectors is:

$$[3\,M^2\,(1-\mu)/2] + [M^2\,(1+\mu)/2] = M^2\,(2-\mu);$$

whereas the number of state vectors with one head and one tail is:

$$[M^2\,(1-\mu)/2] + [M^2\,(1+\mu)/2] = M^2$$

Thus we find that the probability of finding one head and one tail is:

$$p_{HT} = 1/(2-\mu).$$

This is plotted against the indistinguishability parameter in Fig. 1. The circles indicate the possible

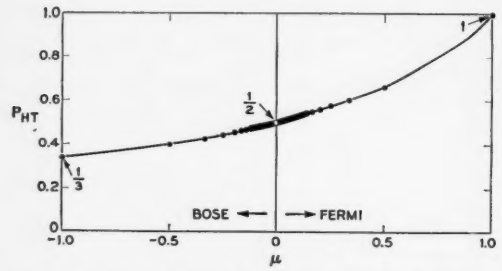

Fig. 1. Probability of tossing one head and one tail as a function of the indistinguishability parameter.

values of μ, determined by the fact that $1/\mu$ must be a positive or negative integer. The three limiting cases of the first paragraph are apparent.

As an illustration, consider the case of two coins which are completely indistinguishable except that each has a spin S; this gives $p_{HT} = (2S + 1)/(4S + 2 \mp 1)$. Thus the probability of getting one head and one tail is 2/3 for Fermi coins of spin one-half and 3/7 for Bose coins of spin one. For very large spins, the probability approaches its classical value.

Gabriel Weinreich

Bell Telephone Laboratories,
Murray Hill, New Jersey, U.S.A.

Loss of Information brought about by Loss of Data

Loss of data from an experiment can diminish the accuracy of estimation of a treatment mean in two ways, by reducing (1) the number of observations on which the mean is based, and (2) the efficiency of estimation. It is assumed that the design was initially orthogonal, and that missing plot values are to be substituted in the usual way. Taylor[1] has studied the effect of missing plots on the standard errors of the differences of treatment means in randomized block designs; recently I needed to know the effect on the errors of the means themselves.

To this end I worked out exact solutions in two cases, (1) where plots are missing for all combinations of certain blocks and treatments, the data being otherwise complete, and (2) where no two of the plots missing have a block or treatment in common. The results suggested an approximate solution in the general case, as follows: If a trial is designed with b blocks and t treatments, so that it is expected to have $f=(b-1)(t-1)$ degrees of freedom for error, then, if a plot is missing from treatment p and block q, and there are (1) j plots missing in all from treatment p, (2) k plots missing in all from block q, and (3) h plots missing from treatments other than p but in blocks containing an existing plot of p, the loss of effective replication brought about by the loss of this plot is not one, but:

$$1 + \frac{b-j}{b(t-k)+j} + \frac{hbt}{f(f+t)^2}.$$

The last term is usually negligible.

I have tested this approximation in a number of instances, and it has always given the effective replication correct to within 2 per cent, provided (1) not more than one-fifth of the total data of the experiment are missing, and (2) each block retains at least two plots. (If a block retained only one, it were better omitted anyway.)

To take an example, let there be four blocks each of five treatments, and four missing plots disposed as follows:

Treatment	*A*	*B*	*C*	*D*	*E*
Block I	*M*	*M*	.	.	.
II	*M*	.	.	.	.
III	.	*M*	.	.	.
IV	.	.	.	.	.

According to the approximation the effective degree of replication of treatment B is:

$$4 - \left(1 + \frac{2}{4.3+2} + \frac{4.5}{12.17^2}\right) - \left(1 + \frac{2}{4.4+2} + \frac{4.5}{12.17^2}\right).$$

which equals 1·73. The exact figure is 1·75.

S. C. Pearce

East Malling Research Station,
Kent.

August 11.

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